AIR POLLUTION—1970

Part 3

JOINT HEARINGS

BEFORE THE

SUBCOMMITTEE ON AIR AND WATER POLLUTION

OF THE

COMMITTEE ON PUBLIC WORKS

AND THE

COMMITTEE ON COMMERCE UNITED STATES SENATE

NINETY-FIRST CONGRESS
SECOND SESSION
ON

S. 3229, S. 3466, and S. 3546

MARCH 24 AND 25, 1970

Printed for the use of the Committees on Public Works and Commerce

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AIR POLLUTION—1970

TUESDAY, MARCH 24, 1970

U.S. SENATE,
JOINT MEETING OF THE SUBCOMMITTEE ON AIR AND
WATER POLLUTION OF THE COMMITTEE ON PUBLIC
WORKS AND THE COMMERCE COMMITTEE,
Washington, D.C.

The subcommittee met at 9:30 a.m., pursuant to recess, in room 4200, New Senate Office Building, Senator Thomas F. Eagleton (member of the subcommittee) presiding, pro tem.

Present: Senators Randolph, Muskie, Eagleton, Cooper, Baker, and Dole.

Also present: Senators Magnuson, Hart, Moss, and Pearson.

Staff members present: Richard B. Royce, chief clerk and staff director; M. Barry Meyer, counsel; Bailey Guard, assistant chief clerk, minority; Tom Jorling, minority counsel; Leon G. Billings and Adrien Waller, professional staff members.

Senator EAGLETON (presiding). Good morning.

The full Commerce Committee is sitting jointly this morning with the Subcommittee on Air and Water Pollution of the Committee on Public Works, which is now in session to continue its hearings on S. 3229, S. 3466, and S. 3546.

The first witness this morning is the Honorable Thomas S. Kleppe, of the U.S. House of Representatives.

Congressman Kleppe.

STATEMENT OF HON. THOMAS S. KLEPPE, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NORTH DAKOTA

Mr. KLEPPE. Thank you, Mr. Chairman.

Members of both committees, I appreciate this opportunity to testify on air pollution control legislation.

My testimony today relates exclusively to the advantages of combining gasoline with alcohol made from grain to produce a cleaner burning motor vehicle fuel. I believe a strong start in this direction could be made within the framework of amendments to the Clean Air Act proposed by many Members of Congress, including myself.

On February 16, 1970, I wrote to President Nixon suggesting that he instruct affected Federal agencies to investigate the possibilities of utilizing the alcohol-gasoline blend as a means of combating air pollution.

There is nothing new about the basic idea. For many years it has been extensively discussed, studied, and tested. Today, with the great national interest in our total environment and with the serious air pollution caused by motor vehicle exhausts, it may be an idea whose time has finally come.

There isn't any question that an alcohol-gasoline blend will work efficiently in present-day motor vehicles. It will measurably reduce hydrocarbon exhaust emissions by as much as 50 percent, some tests show. It will prolong engine life. It will provide extra power, without a tetraethyl-lead additive. It has long been used successfully in other countries.

The obvious question is: Why aren't we using it? The answer, up to now, has always been: Cost.

Back in the middle 1950's, President Eisenhower appointed a commission to study increased industrial uses of agricultural products. Then the principal objective was to expand markets for surplus farm products. The projected cost of producing alcohol from grain led the commission to conclude that it would be "impracticable to recommend an alcohol motor-fuel program."

The urgent need to control air pollution, to regulate automobile emissions of carbon monoxide and hydrocarbons, places the cost factor of converting grain to alcohol in a different perspective now. Moreover, large-scale conversion of grain to alcohol could literally save billions of dollars of farm program costs.

In his message to Congress on the environment, the President pointed out that most air pollution is produced by the burning of fuels. About half is produced by motor vehicles.

The proposed amendments to the Clean Air Act would empower the Secretary of Health, Education and Welfare to "establish standards respecting the chemical or physical properties of any motor vehicle fuel or fuel additive to assure that such fuel or fuel additive will not cause or contribute to emission which would endanger the public health or welfare. * * *"

Even though new engine designs, more lead-free gasolines and improved exhaust control devices will come during the 1970's, millions of motor vehicles now on the road and to be built in the next few years will be operating well into the 1980's. It would appear on the basis of what we already know, that immediate implementation of an alcohol-gasoline program is fully warranted. We could begin on a limited basis almost overnight. The mood and the money were not there in the past but they are today.

I believe what is needed now, to get a large-scale alcohol-gasoline fuel "on the road," is convincing proof that it can be done economically. We must look not only at the first cost of extracting alcohol from grain but also at the value of the high protein byproduct which remains as a food and feed source. We must consider what a cleaner-burning lead-free motor vehicle fuel would be worth from both a public health and dollar standpoint.

We must consider the savings in farm program and price support costs which would result from the elimination of production controls and payments to farmers for diverting wheat and feed grain acreage. This would be the neighborhood of $2 billion a year and there would be further savings of perhaps half a billion dollars in storage, interest and admnistrative costs borne by USDA.

In other words, we must look at the many "offsets" against the cost of producing alcohol from grain. Viewed that way, I am reasonably convinced that alcohol can be made from grain at relatively low cost—low enough to make it economical and practical as an automotive fuel.

Although the petroleum industry opposed this concept in the past, for obvious reasons we have a far different situation today. Like it or not, the industry will have to come up with a much cleaner-burning and probably lead-free fuel or alternative power sources will inevitably be developed. The State of California is now buying automobiles powered with bottled gas. Battery-powered automobiles—we had some years ago—are being considered again. Some say we should go back to the Stanley Steamer.

I may add, Mr. Chairman, the Secretary of HEW, Mr. Finch, is putting on display a steam automobile in the vacant lot just opposite the Cannon Building.

It has been suggested, facetiously I am sure, that a 100-mile-long extension cord could be hooked up to the dream car of the future

Alcohol is also made from petroleum products. This certainly gives the petroleum industry a major stake in the development of alcohol-gasoline fuels. Moreover, the petroleum reserves of the United States are neither unlimited nor renewable. Alcohol from grain is, of course, a renewable resource.

Although industry now has the capacity for producing considerable amounts of alcohol, a mammoth expansion would be required to convert 3 or 4 billion bushels of grain into this form each year. Several hundred plants, costing several billions of dollars, would have to be constructed. If the petroleum industry shifts from tetraethyl-leaded gasolines to the more costly refining processes necessary to produce higher-octane, nonleaded products, the transition would be at least as expensive.

The president of Union Oil Co. says on this:

> Several years will be required to construct the needed new refining equipment. The total capital cost of installing new refining equipment nationwide to add 7 octane numbers is estimated to be between $5 billion and $6 billion. Because of limited construction capacity, it is impossible for all major refineries to add such needed equipment in a time schedule that may be required by law.

So I ask, why not go the other route? Why not start now with production of the alcohol-gasoline blend?

The implications of this for the Nation's farm economy would be enormous. I would like to add here also, Mr. Chairman, we gave much time and thought in promoting rural development. If there is one way to motivate and boost rural development it could be with activity of additional grain production such as this product would involve.

For years we have sought to obtain new industries for rural areas. Certainly it would make sense to locate alcohol extraction plants where the grain is produced.

If we "freed up" our millions of retired acres for all-out grain production, both the farm economy and the total economy would get a much-needed boost. It would take more machinery, more gasoline—blended with alcohol. More fertilizer, more labor, more transportation, more of everything that goes into farm production and the transportation and utilization of agricultural commodities.

It would open the way for tremendous increases in the development of higher yielding wheats and other grains which might not meet present-day milling standards but which would be entirely suitable for conversion into alcohol. Today there is advanced experimentation on a duram wheat-rye cross—Triticale—which has tremendous yield potential, as much as 200 bushels per acre on a dryland farm, according to some reports.

There is no doubt in my mind that by putting our idle acres to work and, at the same time, utilizing more fully the higher yielding grain varieties, the United States could easily produce the extra 3 billion or more bushels needed to meet motor vehicle fuel requirements. There would still be enough—a safe margin—to meet both domestic and export requirements.

As of January 31, 1970, Commodity Credit Corporation had under price support loan and under actual ownership 1,762,399,000 bushels of feed grains and 862 million bushels of wheat. Both of these totals are up substantially over a year earlier.

These quantities of grain are not all to be counted as surpluses. Conservatively, though, I would say about half of the totals could be so classified. In other words, we have more than enough grain available now to swamp existing facilities for converting grain to alcohol. By the time additional facilities were available, farm production could easily be increased sufficiently to keep them operating at full capacity.

I have received a few letters from people around the country who say it is criminal to talk about converting grain to motor vehicle fuel at a time when there are millions of hungry people in the United States and hundreds of millions throughout the world. If this is true, then it is also immoral to impose production restrictions on American farmers today. What I am proposing, essentially, is a program under which we would continue to supply at least as much food grain to our own people and to those around the world as we are today. The grain for alcohol would come from increased American production—from our idle acres and the higher yielding crop varieties.

Then there is the question of cost—both to the Government and to the user of the alcohol-gasoline blend. When the "offsets" I mentioned are cranked into the equation, it seems to me that the Government would gain, both in farm programs savings and in the incalculable benefits which would result from cleaner air.

From the motorist's point of view, I believe a blend of 10 or 12 percent of grain alcohol with gasoline will cost him little more than the higher octane, nonleaded gasoline he will be using in the future if the decision is made to rely entirely on what the Union Oil Co. calls "more severe refining processes". If the "offsets" are fully weighed, it may well be less.

In fact, the motorist using the alcohol-gasoline blend would receive as a bonus, instead of green stamps or a free candy bar, actual dollar savings through the longer and more trouble-free operation of his automobile engine.

It seems to me that the transition to the alcohol-gasoline blend could be made in an orderly way, without disrupting the petroleum industry, the automotive industry or the farm economy. We could start now, in a limited way, with what we have available. There is time to smooth out the bumps in the road ahead before we get there. It will take some planning, some ingenuity and some determination. But it can be done.

I am encouraged by the support I have received not only from the public but also from Members of Congress, scientists and others concerned with the air pollution problem. It is time to bring this dream, so long held by American farmers, to reality.

(The letters' accompanying Representative Kleppe's statement follow:)

CONGRESS OF THE UNITED STATES,
HOUSE OF REPRESENTATIVES,
Washington, D.C., February 18, 1970.

Hon. EDMUND S. MUSKIE,
Chairman, Subcommitteee on Air and Water Pollution, Committee on Public Works, U.S. Senate, Washington, D.C.

DEAR SENATOR: At a time when both air pollution and accumulating surpluses of agricultural commodities are serious national problems, it is appropriate to consider a plan which would measurably reduce both.

This could be accomplished through the blending of alcohol made from grain with gasoline to produce a cleaner-burning motor vehicle fuel which would reduce hydrocarbons in exhausts by as much as 50 per cent and cut farm program costs and surpluses in the process.

I invite your consideration of this proposal which I have outlined in a letter to the President.

Sincerely,

TOM KLEPPE, M.C.

(Letter to President Nixon follows:)

CONGRESS OF THE UNITED STATES,
HOUSE OF REPRESENTATIVES,
Washington, D.C., February 16, 1970.

Hon. RICHARD M. NIXON,
President of the United States,
The White House, Washington, D.C.

DEAR MR. PRESIDENT: A cleaner-burning motor vehicle fuel combining gasoline with alcohol made from grain may be an idea whose time has finally come.

I know you will recall this was one of the possibilities studied by the Commission on Increased Industrial Use of Agricultural Products which reported its findings to you, as President of the Senate, and to the Speaker of the House on June 15, 1957.

Then the principal objective was to expand markets for surplus farm products. The projected cost of producing alcohol from grain—perhaps 40 or 50 cents per gallon—led the Commission to conclude that it would be "impracticable to recommend an alcohol motor-fuel program."

Economic utilization of surplus U.S. grains remains a problem as acute as it was in 1957. However, the urgent need to control air pollution—to regulate automobile emissions of carbon monoxide and hydrocarbons—places the cost factor of converting grain to alcohol in a different perspective. Moreover, large-scale conversion of grain to alcohol could literally save billions of dollars of farm program costs.

In the February 10 Message to Congress on the Environment, you pointed out that "Most air pollution is produced by the burning of fuels. About half is produced by motor vehicles."

To implement the recommendations set forth in your Message, the Secretary of Health, Education and Welfare submitted to the Congress on February 11 proposed amendments to the Clean Air Act which would empower him to "establish standards respecting the chemical or physical properties of any (motor vehicle) fuel or fuel additive to assure that such fuel or fuel additive will not cause or contribute to emissions which would endanger the public health or welfare . . ."

Although the feasibility of blending alcohol with gasoline obviously demands further study and re-evaluation, it seems to me there is a most challenging opportunity to attack both the problems of air pollution and agricultural surpluses. The Southwest Research Institute at San Antonio and Houston has done a considerable amount of research in this field. A copy of one of their reports (1964) is enclosed.

From experiments conducted there and elsewhere, over a considerable period, it would appear that:

1. The alcohol-gasoline blend will work satisfactorily in present-day automobile engines, without serious drawbacks in performance or economy.

2. A blend consisting of 25 per cent 200-proof ethyl alcohol will reduce hydrocarbon emissions by as much as 50 per cent, with some reduction of oxides of nitrogen under certain conditions.

3. The blend greatly reduces combustion chamber deposits and this should prolong engine life.

Although the blend does not provide a complete solution to the problem of air pollution created by motor vehicles, it could help to provide substantial relief, especially in the smog-saturated areas. Use of this product could be commenced on a limited basis, almost immediately. With some engine and carburetor modifications, higher performance standards could undoubtedly be obtained.

Even though new engine designs and improved exhaust control devices will come during the 1970's, millions of motor vehicles now on the road and to be built in the next few years will still be operating into the 1980's. The blend is primarily for these older vehicles.

It would appear on the basis of what we already know, that further immediate and greatly-expanded research in the alcohol-gasoline field is fully warranted. The mood and the money were not there in the past but they are today.

It seems to me that there are several important factors to be considered in connection with the cost of producing grain alcohol:

First, the 1971 Federal Budget projects costs of $3.8 billion for programs to strengthen farm prices and income. A sizeable part of this will go toward paying farmers for diverting or retiring acreage from production and to bolster the price of commodities harvested on planted acreas. The cost of storing government-owned commodities is also heavy. Large-scale utilization of grain alcohol in motor fuels would not only eliminate present surpluses in fairly short order but would also make it possible to remove all acreage controls on such crops as corn and wheat. I believe that as much as 4 billion bushels of grain could be used annually in motor fuels. This would inevitably raise farm prices and free producers from controls. Most of the present farm program expenditures could be eliminated or drastically reduced, with perhaps only a minimum price guarantee remaining—a tool which would probably be infrequently, if ever, used. Farm income would increase sharply giving agricultural producers the real "parity" with other segments of the economy that they have never achieved.

Second, part of the savings in farm program costs could be used to subsidize the use of alcohol in motor fuels, if this became necessary.

Third, because alcohol is produced from the starch in grain, there would remain a large, high protein byproduct which could be utilized in many ways, including upgrading into food for human consumption. This is being done now in at least one Indiana plant. The value of this byproduct would hold down the cost of producing the alcohol and might largely offset it, if expanded markets were developed.

Fourth, for many years each succeeding Administration has sought, with only limited success, to develop new industries in rural areas. It would seem highly feasible to locate conversion plants where grain is actually produced.

I am enthusiastic over the possibilities of such a program. Because of the major role which the Department of Health, Education and Welfare will play in the area of future motor vehicle fuel specifications, I am also transmitting to Secretary Finch the thoughts incorporated here. It seems to me that this is an especially appropriate time to give thorough consideration to the promising possibilities of reducing air pollution and, at the same time, finding greatly-increased use of surplus farm crops.

Sincerely,

TOM KLEPPE, M.C.

Senator EAGLETON. Thank you, Congressman Kleppe.

I will now yield to Senator Hart of Michigan.

Senator HART. Congressman Kleppe, thank you very much for highlighting what used to be sort of a semi-joke and today a reality, the possibility you dramatically suggest is we should move.

Mr. KLEPPE. Thank you very much, Senator.

Senator EAGLETON. Senator Pearson of Kansas.

Senator PEARSON. I have no questions, Mr. Chairman.

It is an excellent statement, Congressman. I find myself in almost total agreement with everything you say.

Mr. KLEPPE. Thank you very much.

Chairman MUSKIE (presiding). Senator Moss?

Senator MOSS. Thank you, Mr. Chairman.

I wish to congratulate the Congressman for his statement. As Senator Hart indicated, we now are beginning to look with great seriousness to things that just a very few years ago seemed far-fetched and impractical but the pressures of pollution and environmental degradation are on us and we have to look seriously. You have given us a suggested way that is very interesting and one that certainly we ought to consider. Thank you very much.

Mr. KLEPPE. Senator, I appreciate those comments. Certainly we have a new motivation today as we look at this problem because of pollution and because of the desires of the public to have something done about it. Thank you for those kind remarks.

Cochairman MUSKIE. Senator Dole.

Senator DOLE. Thank you very much.

I have a question for Congressman Kleppe. First, having served with him on the House Committee on Agriculture, I commend Congressman Kleppe for his efforts in this new area. I wholeheartedly endorse his proposal.

The distinguished Congressman from North Dakota has testified to the possible use of alcohol made from grain in a mixture with gasoline as a motor fuel. This, of course, is not a new idea, but in the past has proven uneconomical since the cost of alcohol has been too high and therefore the alcohol-gasoline blend would not be competitive. Congressman Kleppe was able to see new overall benefits from the possible use of alcohol made from grain with our recent emphasis on the elimination of air pollution. I commend his awareness and vision in observing the many offsetting benefits of this prospect with regard to air pollution from auto emission.

Mr. Chairman, following the remarks of Congressman Kleppe, I request permission to insert in the record a letter I addressed to the President with reference to this proposal.

Cochairman MUSKIE. Without objection it is so ordered.

(The letter follows:)

U.S. SENATE,
Washington, D.C., March 10, 1970.

HON. RICHARD M. NIXON,
The President,
The White House, Washington, D.C.

DEAR MR. PRESIDENT: You recently received a letter from Congressman Tom Kleppe requesting expanded research into the use of an alcohol-gasoline mixture as fuel for automobiles to reduce pollution from exhaust emission. I strongly endorse Congressman Kleppe's proposal.

The State of Nebraska recently sponsored a study on the use of grain-based alcohol as an additive. The study indicated a reduction in the level of emission of unburned hydrocarbons compared with conventional additives. Combining these efficiencies with emission control devices on new automobiles could result in the desired reduction of 80 to 90% (California standard) in emission of hydrocarbons.

The use of the mixture could also control pollution from old cars not equipped with emission control devices and eliminate any need for installation of such devices on old cars.

A beneficial prospect of equal magnitude is the use of grain as the raw product from which the alcohol could be manufactured. In our studies of farm legislation in the Senate Agriculture and Forestry Committee, the need to stimulate demand is apparent. Corn, wheat and grain sorghum are greatly affected by decreasing export demand.

Projecting the benefits of implementation of such a proposal further, to process over 3 billion bushels of grain, the Agricultural Research Service of the Department of Agriculture has indicated it would require the construction of 500 fermentation plants to process the grain. The location of these plants in the grain producing areas would result in obvious benefits in rural development in keeping with your repeated concern over the continuing migration of rural residents to urban centers.

In summary, the beneficial prospects of utilizing grain-based alcohol in a mixture with gasoline as fuel for internal combustion engines are:

(1) Reduction of air pollution from automobile exhaust emission.
(2) Improving the demand for Agricultural production.
(3) Providing a new source of protein in the refining byproduct.
(4) A means to help retard and possibly reverse rural-urban migration.

The Department of Agriculture has researched this prospect as it would relate to utilization of grain. The Department of Health, Education and Welfare has researched it through their National Air Pollution Control Administration. The Department of Transportation is researching this proposal. The Department of Housing and Urban Development would be interested in this proposal to the extent that it could help develop rural communities.

I respectfully suggest a Task Force combining the efforts of the four Departments be created to take a broad look at this proposal from a social as well as an economic standpoint.

The Task Force could properly investigate the following possibilities in their respective areas:

(1) Pilot Project to determine actual effectiveness in a community with regard to air pollution.

(2) Further study of potential uses of the refining byproduct and projection of a value to decrease the cost of producing alcohol.

(3) Projection of the possible savings in government farm programs as a new demand is created for grain.

(4) Effective utilization of the fermentation plants and their relation to developing a more attractive rural America to halt the migration to the urban centers.

(5) Basic personal benefit to the consumer who will be asked to use this mixture including such things as longer engine life, cleaner burning with no deposits, etc.

Singly the present research has produced some negative response, and I realize there are interests who will be against such a proposal from the start. However, a Task Force overview may well provide multiple benefits that far exceed any individual analysis.

Your sympathetic consideration of this plan is hereby solicited, and I pledge my cooperation in its furtherance.

Sincerely yours,

BOB DOLE,
U.S. Senate.

Senator DOLE. Let me ask Congressman Kleppe, can use of the alcohol fuel blend be implemented immediately? Can you convert without any special equipment, or is that known yet?

Mr. KLEPPE. Yes. As I understand it works fine in today's cars. A 10- to 12-percent blend with gasoline in our present engine works very well. This is the basis of my approach to getting into some kind of a test operation or pilot operation on an alcohol blend rather soon.

Senator DOLE. Another area of importance to those of us from rural States—North Dakota, Kansas, Utah, Maine and parts of Michigan is the farm program and its cost. As I understand, if this plan described by Congressman Kleppe is implemented and the fuel developed, we would save in the neighborhood of $2 billion. I would also guess that it would increase the demand for grain and also the price for grain.

Mr. KLEPPE. I question the situation on price. It certainly would increase the demand for grain, which to me kind of lights up the eyeballs when you think about it because today we have so many acres out of production. When I think of farmers in rural American putting the drill in the ground and going section line to section line to produce grain for a use other than what we have today, which would consume considerable quantities, I think of a complete rejuvenition of rural America where grains that could be used to produce alcohol would be raised. I do not think that the price factor would throw it out of line because of the competition between the various types of grain that could be used such as wheat, corn, grain sorghum, and what have you. So I don't think that the question of price is a deterrent here, from the standpoint of moving ahead, but most assuredly demand would equalize and correct a surplus problem that we have lived with for years in agricultural America.

Senator DOLE. As you indicate if there was a pilot project we could determine some of the unanswered questions and particularly if it does hold hope for assisting rural areas.

Again I commend you and emphasize, as you did, that this is not a new idea but you have a new approach to it, one that I strongly feel deserves very serious consideration.

Thank you.

Mr. KLEPPE. Mr. Chairman, if I may add here I would like to especially thank the Senator from Kansas for his support on my approach to this. I did get a copy of a letter that he sent to the President and he, too, recognizes and understands the problems in rural America. I am very appreciative of his support and his efforts. I hope something can come of it.

Cochairman MUSKIE. Thank you very much, Congressman.

I apologize for not being here to hear your statement. I was tied up elsewhere. But I glanced through it and I would like to compliment you on your imaginative approach. I think that we need ideas if we are really going to deal with this problem effectively. We like to think of this committee as the forum for the exposure of new ideas. I assure you we give every consideration to what you propose here.

Mr. KLEPPE. Mr. Chairman, I thank you for the time and opportunity to appear before your committee.

(The following articles from the Montana Farmer-Stockman, January 15, 1970, were submitted for inclusion in the record by Max Rasmussen, Antelope, Mont.:)

[From the Montana Farmer-Stockman, Jan. 15, 1970]

WHEAT FOR MOTOR FUEL

(By Ted Sorenson)

In an attempt to boost the lagging agricultural economy of the state, the Department of Planning and Economic Development is exploring the possibility of within-state utilization and processing of farm products. One possibility being considered is that of commercial feed lots with capacities of 25 to 30 thousand head with an annual turnover of 2 to 2.5 times. We have been sending livestock out of the state, and then sending grain after them far too long. The agricultural community cannot afford this type of operation. We should strive for an additional 20 to 30 million bushels use of Montana grain.

Because of the low price of wheat our barley exports are nil. If the California barley crop had been good last year, we would have seen much lower prices for this product. To move a ton of barley to California costs over $20 a ton, to Arizona $14 a ton. The cost of shipping cattle out is around $2 per hundred. These cost factors make feeding Montana grown grain to Montana produced livestock attractive. The possibility of processing meat and air freighting it to markets would bring us as close to the large cities and urban markets, time wise, as any feed lot and processing plant in the United States—without the effort and expense required to ship vast quantities of unfinished product out of the state for consumption and processing.

In the late 1920s and early 1930s, when American agriculture went from animal power to tractor power, the source of energy was shifted from grains and pasture to fossil fuels, thus releasing millions of acres for the production of additional grain products. This, combined with mechanical horsepower and advanced technology in plant breeding has produced surpluses such as the world has never known. Agriculture is so production oriented that little attention, other than lip service, has been given to alleviate these surpluses through efficient marketing and within-state utilization of farm products.

In our modern-day society we have been called to confront many problems, not the least serious of which is air pollution. The battle cry against this menace is being sounded in all areas of our nation, rural communities included; now it seems probable that our rural population will bring at least a partial lessening of this problem.

Pollution is caused to a great extent by internal combustion engines using fossil fuels with lead tetra ethyl additive to raise the octane, enabling low grade gasolines to be used in high compression engines. But in Australia, for example, power (grain) alcohol is added to gasoline, providing even better results. In the "Women's Weekly" of April 1, 1969, an Australian magazine, a full page ad is run on the benefits of adding power alcohol to gasoline. The ad is run by AMOCO and they make the statement that theirs is the only fuel that will give this type of performance. A significant reduction of hydrocarbons into the atmosphere could be achieved in this manner. In large cities and urban areas, power alcohol could be a step forward in the fight against air pollution.

Power alcohol could also be used in farm fuels. It would be a cheap source of additional horsepower, much more so than paying from $1.00 to $1.50 a pound for steel in a larger farm tractor and attempting to pay for it with dollar wheat and 70 cent barley, the principal small grain crops in Montana. One bushel of wheat will produce 2.7 gallons of alcohol; about 22 pounds of barley will produce a gallon of alcohol, although the by-product of barley may run higher in fiber than does wheat. There is no protein loss in the extraction of alcohol from the grain as a rule.

In the manufacture of industrial alcohol, all possible economy measures must be exercised. Each manufacturing plant should be located in a grain producing area to minimize transportation costs, with an integrated plant in close proximity which would make use of the by-products of the alcohol process. The by-product is a highly concentrated animal feed. It should be fed at the source of production to minimize drying costs, fuel, sales costs, storage and transportation costs. This is a very desirable feed for poultry and hogs, but for cattle a barley supplement is needed. The by-product recovery rate is about 6 pounds per gallon of alcohol produced.

I favor the use of feed grain for an operation of this type to get away from the objection of using a grain that could be used for human consumption. This is not a new idea—in some European countries the distillation of alcohol for energy is over 70 years old.

Another possible use for this alcohol is heating homes in rural areas—alcohol will burn but will not explode unless under compression. The safety factor in the use of this type of fuel should be explored. The utilization of barley for industrial alcohol could make barley a desirable crop to raise from an economic standpoint, probably resulting in a minimum of wheat acres. Low grade wheat can be used also when supply exceeds demand.

The industrial use of alcohol could become a reality as soon as agriculture is ready to do something about it. One place we could start without any fear of failure would be supplying agriculture's needs. During the 1930's, chemists and engineers at Iowa State College, Ames, Iowa, spent years in research, study, experimentation and road tests to prove the efficiency and sound value of grain alcohol blended with the gasoline to be superior motor fuel.

In 1933 the Illinois Agricultural Association distributed approximately 500,000 gallons of 10 percent blend of alcohol-gas to the general public for test purposes and report. (Keep in mind a blend of 10 to 25 percent alcohol would require no carburetor change.) Out of a total of 1,374 customers and users:

1,149 reported easier, quicker starting;

1,308 reported increased acceleration;

1,293 reported less "knock";

1,291 reported increased power;

1,301 reported general performance of the motor better:

1,329 reported the trade would pay a premium if necessary to obtain the alcohol blend.

Another test was conducted at Yankton, S.D. using 200,000 gallons. The findings were about the same.

The blends can be stored indefinitely without deterioration. Alcohol blended with third grade gasoline was equal to premium fuels using leads.

Agriculture can solve its own surplus problem by using grain alcohol in fuel. It is economically feasible. We can do it if we want to.

"Agri-gas"—A New Market for Wheat?

(By Mike Wohld)

A simple, but dramatic demonstration by an Oregon wheat grower—the comparison of two different automobile tail pipes—is sparking interest in "agri-gas" these days.

Agri-gas? That's unleaded gasoline . . . blended with ethyl alcohol . . . manufactured from farm crops. Any brand new market possibility for farm products is of major interest to the agri-business world. This one shows real promise.

"Put your finger in this tail pipe," James Q. Johnson directs with a noticeable grin. "Clean—isn't it." He then grabs your arm escorts you to another car. Your finger gets dirty in its exhaust.

Johnson's station wagon had been running on a mixture of white gasoline (no tetraethyl lead added) and ethyl alcohol. The other car had been burning ordinary gasoline with tetraethyl lead, the "antiknock" ingredient in most—if not all—the gasoline consumed by autos in the United States.

Johnson's tail pipe demonstration, which he performs for anyone that will give him the opportunity—including Oregon Governor Tom McCall last month is to illustrate what "agri-gas" might do to help curb air pollution from cars. Auto fumes are reportedly one of the major sources of air pollution (60 percent or more, according to some estimates) in the U.S.

Agri-gas could create a new wheat market, raise the price of wheat, reduce pollution of the air and provide high-protein human food and livestock feed, according to the two men who started to seriously promote the current interest in agri-gas about two years ago. They are Frank P. Adams, manager of the Interior Elevator Company at The Dalles, Oreg., and Gail R. Holzapfel, Wasco, Oreg., Sherman County wheat farmer and president of the company.

"We are going to push it for all it's worth," said Richard L. Skiles of Wasco, Sherman County wheat farmer and new president of the Oregon Wheat Growers League.

Making gas from grain and other farm crops is nothing new. European countries were burning ethyl alcohol manufacturer from surplus crops in the 1930's to reduce their dependence on foreign imports of crude oil and to provide another market for their crops, according to a USDA study published in 1933. "Experience in the United States and in many foreign countries has demonstrated that alcohol, manufactured from farm products, can be used successfully as motor fuel in a blend with gasoline . . . Alcohol added to gasoline raises the antiknock rating; improves combustion, the tending to prevent carbon formation; and in general makes but smoother engine operation," according to that same study published during the depression. And farmers, struggling with overproduction and low prices, hoped agri-gas might bail them out by consuming surplus grains. Several plants were reportedly constructed in the U.S. (including one near Arlington, Oreg., according to Johnson) to manufacture alcohol from surplus crops. Hopes for a massive alcohol fuel industry sputtered and died, however.

Then in 1961 the same idea was revived by Donald Despain in a 260-page book, "The One and Only Solution to the Farm Problem." Despain had been an advertising man, commissioner of agriculture for Nebraska, industrial relations consultant and author of several books and pamphlets, one of which called for bank deposit insurance. Despain, in his book, argued for agri-gas on the grounds that it would provide a profitable outlet for maximum crop production, raise farm income, get the government out of agriculture, and conserve crude oil supplies among other things. He also criticized and blamed oil companies for defeating previous attempts by farmers to get legislation requiring that motor fuel be a blend of ethyl alcohol and unleaded gasoline.

CAMPAIGN TIMELY

Currently, manufacturing agri-gas has a unique and timely thrust behind it. Holzapfel, Adams and other wheatgrowers contend that replacing tetraethyl lead, the so-called "antiknock" additive in gasoline, with ethyl alcohol—about a 10 percent mix—would eliminate a substantial amount of pollutants now being emitted into the air from car exhausts. The public wants clean air; here's one way of making it cleaner, Holzapfel, Adams and Johnson will tell you. Dr. Clair C. Patterson, a geochemist in the Division of Geological Science at the California Institute of Technology, agrees. Oregon wheatgrowers invited Patterson to their annual meeting last month.

"Today the exposure of the average person to industrial lead is so severe that it is estimated he carries 100 times more lead in his body than he should under natural conditions," according to Patterson. End result of too much lead can be "classical lead poisoning," he said.

"One of the main identifiable sources of lead pollution to humans is from leaded gasoline exhausts," Patterson continued.

"Lead tetraethyl is put into gasoline because it allows poor grades of fuel to be used in high-compression engines by increasing the 'anti-knock' properties of the fuel," according to Patterson. "A solution of the problem would be to refine better quality fuels at an additional cost of one or two cents per gallon. It would take considerable time to alter present refineries to accomplish this task.

"An interim solution which would permit lead to be eliminated from fuels at an earlier date would be the use of a benign substitute, such as ethyl alcohol in the place of lead tetraethyl." Patterson estimated about one pint of alcohol would be needed per gallon of gasoline.

HYDROCARBONS WOULD BE REDUCED

Aside from the alleged lead posioning properties of car exhausts there are reliable reports suggesting that lead in the gasoline leaves deposits in the engines that cause greater emissions of unburned fuel (THE WALL STREET JOURNAL, Jan. 30, 1969). Patterson contends that eliminating lead from gasoline would reduce hydrocarbons pushed into the atmosphere from car exhausts. "Catalytic afterburners," which completely combust "deleterious hydrocarbons" are rendered "ineffective" by the tetraethyl lead in gasoline, says Patterson.

Assuming agri-gas could effectively serve up cleaner air for urban dwellers, wheatgrowers have good reason to be excited about the possibilities of a new and profitable market for their wheat. However, a number of questions have no doubt entered the reader's mind, questions which the Oregon Wheat Growers League hopes to have answered by research.

Would ethyl alcohol be an economical substitute for lead? Patterson, although admittedly not an economist, thinks so. Costs of ethyl alcohol are "competitive with the costs of lead tetraethyl," he said.

"Alcohol would be the by-product," points out Adams. He suggests that much of the income from wheat would be in high-protein human food and animal feed. There are processes that can efficiently extract the alcohol from the starch and deliver up the wheat food and feed products, Adams said.

About 2½ billion bushels of wheat would be needed to produce enough ethyl alcohol annually for a 10 percent blend that would meet current gasoline consumption in the U.S., Holzapfel has estimated. Another estimate puts the figure at 3.2 billion bushels. Less than 2 billion bushels is now being produced in the U.S.

Then the question arises as to whether or not farmers could find a market for all the feed and food that would be produced in the alcohol-making process.

Would the petroleum companies, if forced to remove tetraethyl lead. find it more economical to produce a better grade of gasoline that wouldn't require lead—or ethyl alcohol? Patterson seemed to suggest that this is precisely what they would eventually do when he described ethyl alcohol as an "interim solution." It could be, too, that steam cars or electrically powered cars may someday be on the mass market. Natural gas has also been suggested by some to replace gasoline in cars.

State or federal governments would have to ban lead in gasoline if the agri-gas plan is to ever get started, Holzapfel and Adams have pointed out. They suggested as much as the Oregon State Legislature last year in testimony before the Senate Air and Water Quality Control Committee. Patterson was testifying on the evils of tetraethyl lead in gasoline and a gas industry spokesman was on hand to argue that leaded gasoline isn't a threat to the environment.

Nevertheless, the "agri-gas plan," as many readers will no doubt agree, just might be feasible.

Last month the OWGL went firmly on record to really push the plan along. Resolutions adopted:

"Encourage the Governor (Tom McCall) to pursue his recommendation and conduct a study on the use and markets for protein, starch and alcohol from wheat."

"Favors a campaign to dispense with the use of tetraethyl lead in gasoline because of its polluting effects in the air and encourage all other farm organizations, allied businesses and urban organizations to implement this legislation.

"Favors using the inverse subsidy funds to finance research on uses of wheat and that the funds be controlled by the National Association of Wheat Growers.

"Hire a person to work on air pollution problems and find people to testify at legislative hearings."

Similar resolutions will likely be considered by the National Association of Wheat Growers when they meet in Oklahoma City January 19–22, said retiring OWGL president Tom Vaughan, Jr., Pendleton. Fargher was to have reported to Washington wheatgrowers during their annual meeting in December about Oregon's agri-gas developmentes.

"What we need now," said Vaughan, are:

More studies on the air polluting effects of leaded gasoline.

Experiments with engines to find out how much a mixture of unleaded gasoline and ethyl alcohol will cut down on air pollution and if agri-gas can run engines as effectively or more efficiently than leaded gasoline. Oregon State University mechanical engineers have the engines to run these tests, he said.

Demand for wheat food and feed made in the distilling process must be studied.

"I think we're going to get some of these studies made," Vaughan said.

"Last year everyone was laughing at this thing," said Johnson. Wheatgrowers didn't know enough about the agri-gas plan to take it very seriously, noted Leon Rondeau, Condon, Ore., Gilliam County wheat farmer and vice-chairman of the League's public affairs committee. "Patterson's report on the dangers of lead poisoning change (some) thinking," he said.

Special interests may fight a ban on tetraethyl lead, but public opinion, if aroused like it has been against DDT, can handle that situation, Rondeau asserted.

"We see an opportunity," said 1970 OWGL president Skiles. Gov. McCall, he said, "has shown great interest" in the agri-gas plan. If indisputable evidence can be gathered to show that ethyl alcohol could eliminate a substantial amount of air pollution, "legislation would be in order to require petroleum companies to blend ethyl alcohol with fuel to eliminate tetraethyl lead," Skiles continued.

"Actually, ethyl alcohol should be cheaper (than tetraethyl lead)," Skiles thinks.

A new market must be found for wheat, Skiles said. "White wheat is being phased out in the Asiatic markets," he continued. Wheatgrowers in the Northwest simply can't continue to grow wheat at current prices and costs of production, Skiles, Rondeau and others interviewed, emphatically agree. (County extension agents in the Columbia Basin wheat producing region of Oregon report more wheat farms are up for sale than ever before.) One wheatgrower pointed out that he received $1.78 total per bushel for his wheat in 1965. At 1969 prices he would get from $1.35 to $1.37. His cost of producing the wheat in 1969 was $1.52 per bushel, the farmer said.

"The wheat industry is at a crossroads," said Skiles. "We're either going to lose a lot of our wheat producers or create a demand that is going to help keep them on the farm."

Cochairman Muskie. Our next witness this morning is Dr. Lester W. Sontag of Fels Research Institute, Yellow Springs, Ohio.

Dr. Sontag, it is a pleasure to welcome you this morning.

STATEMENT OF LESTER W. SONTAG, M.D., FELS RESEARCH INSTITUTE, YELLOW SPRINGS, OHIO

Dr. Sontag. Mr. Chairman.

Senator Pearson. May I apologize to the doctor. I have another hearing at 10 and I have to leave, and I don't want to do it while he is making his presentation without an explanation.

Dr. Sontag. The purpose of this manuscript is to present information which will emphasize the necessity for awareness of possible damaging effects of pollutants to human beings before they are born. In the area of sound pollution, there is almost no firm knowledge of the nature of such damage. But there are a few bits of evidence which establish that the fetus is not immune from environmental forces and must be presumed vulnerable to certain pollutants, including sound.

In general, effects of noise can be considered under three headings:

1. Effects of noise upon man's auditory systems;
2. The psychological effect of noise upon man's emotional state and the adequacy of his performance; and
3. The effect of noise on systems other than auditory, for example, cardiac, respiratory systems.

A considerable body of research has been conducted in these three areas with both human and animal subjects.

The effect of noise upon the auditory system of the unborn human is almost completely unexplored despite the ample evidence that the fetus hears sounds in roughly the same range of frequency as does the newborn infant. What little work has been done indicates that the human fetus, like the newborn, responds to any sharp sound such as that emitted by a doorbell, with a startled response, or Moro reflex, consisting of a convulsive movement of the arms and legs and a momentary increase in heart rate. The same fetal startle effect has been reported in response to applause following a popular rendition of a symphony, or certain portions of the concert music itself. These are relatively "ordinary, everyday" stimuli. One might only speculate on the response pattern and its implications when more intense and continuing or repetitive sounds occur, such as a commercial jet noise or sonic booms. It has also been shown that a human fetus can develop a conditioned reflex to an otherwise neutral stimulus in the manner of Pavlov's dog. For example, when a loud sound is repeatedly preceded by a tactile stimulus to the mother's abdomen, the fetus progressively learns that the tactile stimulus signals the impending onset of the loud sound. The fetus anticipates the sound by giving the startle response to the previously neutral tactile stimulus. This kind of conditioned reflex is identical to that which can be induced at later stages of human or animal development.

In other studies, more violent noises repeated at frequent intervals in the presence of pregnant rats can lead to a persistent change in the behavior of the offspring of those mothers. In adolescence, those offspring which were subjected to loud noises as fetuses performed less adequately than nonstimulated animals in learning situations and are more "emotional" in some aspects of their behavior. It is thus suggested that intense sounds introduced during the fetal period might have lasting, nontrivial effects. The sounds themselves may not be as important directly to the fetus as the responses they elicit in the host mother. She may respond physiologically to a variety of sounds and pollutants, pleasant or unpleasant, with anxiety, fear, confusion, elation, pleasure, and so forth. The emotionally induced changes in mothers' endocrine, cardiovascular, and metabolic functions can, through placental interchange, modify the behavior and welfare of the fetus.

On the pleasant side, for example, mothers listening to a musical selection of their choice do not demonstrate a statistically significant change in their own heart rate. However, if they are carrying an 8- or 9-month fetus, the fetus does show a change in heart rate. This response occurs some time after the music begins suggesting that it is a part of his mother's emotional response to the music. To some people music is a profound thing, to other people it is something that comes out of the radio all day long.

There is no reason, certainly, to think this is deleterious to the fetus. I submit it only as evidence that the fetus is part of a total organism and is responsive to some of the variety of stimuli of everyday life, be they music, drugs, cigarettes, or pollutants.

I think that I have demonstrated that the fetus does perceive, directly or psychophysiologically, many of the stresses or stimulations to which its host mother is exposed. Now, if one considers the infinitely greater susceptibilty or vulnerability to damage which is inherent with the beginning of life when cells are being laid down and formed and so aptly demonstrated by the tragic consequences of early maternal rubella infections—German measles—and the body deformity of infants whose mothers used thalidomide during the first 3 months of pregnancy, one must be acutely aware of the possible magnification or damage to the fetus that might be inherent in sonic booms, airport noise, or high-level industrial noise for working pregnant women. It is interesting in this regard that my attention was first drawn to the problem of effects of noise during late pregnancy by the complaints of a farm woman 9-months pregnant of the violent fetal activity she experienced when running an old gasoline-powered washing machine.

Further research with animals indicates that some of the effects of the prenatal environment can persist throughout life and be important determinants of the function and behavior of the adult. There are a number of such experiments in the literature, all of which demonstrate that when conditions were created which were emotionally disturbing to a prospective animal mother, her offspring at adolescence behaved differently in terms of performance and learning than did those of a nonstimulated control group.

It has also been demonstrated in humans that expectant mothers experiencing severe emotional trauma during the last 2 months of pregnancy have offspring which evidence significant differences in terms of activity, level of crying, food tolerance and bowel function and so forth, from nontraumatized fetuses.

It is also true of a biofactor of 5 to 10 times so this emotion is expressed immediately but it is also persistent in terms of behavior of a child for a good many months after birth, at least.

Again, these are examples of postnatal life. While these specific effects were not a function of sound stimulation per se, they nevertheless illustrate the possible results of early psychophysiological stress, one source which is, of course, sound pollution.

In conclusion, I hope that the examples I have cited of the vulnerability of the unborn to environmental stress make it mandatory that we consider very acutely his right to protection from pollutants including, certainly, sound pollutants.

Cochairman MUSKIE. Doctor, you have testified there is evidence of fetuses responding to noise. Have you drawn any conclusions at all about whether that response was lax and unfavorable in fact upon the health of the fetus?

Dr. SONTAG. Yes. I gave you one example of the behavior of adult rats whose mothers had been stimulated by sound during the fetal period. There are also of course a great many experiments which demonstrate that various physiological functions in adults are changed by racus and continuous sound and that these factors would be necessity be a traumatic thing to the fetus.

Cholesterol, for example, has changed, in chronic noise. The body does not handle the ammonias well in continuous noise. There are many other changes, vascular changes. These things I am talking of must in terms of our experience be considered probable damaging factors to the fetus. It is interesting that when the first sulfa drug came on the market, pronosel, I had a little infection and I took some pronosel. It was pretty toxic stuff and I got a headache and nausea and so forth for 2 or 3 days while I was taking it. I put in a scientific publication the fact that it seemed to me we must be concerned. If these things were as toxic to adults as they seemed to be, what would they do to a fetus, a 3-month or 2-month fetus. It was many years after that that thalidomide came in and indicated very dramatically that this was so. How many other drugs are damaging to the fetus that are still not very well known? Our Food and and Drug Administration is very carefully testing the effects on fetal life now on the various new drugs. This is an example of the protection that we must give the human fetus until at least we find out that things don't have a damaging effect.

Cochairman MUSKIE. Would you generalize beyond effects on the fetus to the general conclusion that noise polution is a health problem?

Dr. SONTAG. Oh, yes, and there is a good deal of evidence in the literature on that subject. Various physiological changes are measured.

Cochairman MUSKIE. Thank you very much, Doctor. There are other questions that I would like to get into but our next witness, Secretary Volpe, is here and I want to give my colleagues an opportunity to ask you questions.

Senator Hart.

Senator HART. Thank you, Doctor.

Cochairman MUSKIE. Senator Dole?

Senator DOLE. No questions.

Cochairman **Muskie**. Senator Moss?

Senator **Moss**. I have no questions, Mr. Chairman.

Cochairman **Muskie**. Senator Randolph?

Senator **Randolph**. No.

Cochairman **Muskie**. Thank you very much, Dr. Sontag.

Senator Magnuson has joined the hearing. It is a pleasure to have this opportunity to welcome him as well and to invite him to make any comments that he might like.

Cochairman **Magnuson**. Mr. Chairman, I appreciate joining the Public Works Committee again in joint hearings where we share the same concern about these matters of environment. I have a short statement I would like to put in the record. Obviously, the transportation aspects of pollution are [end of this problem is] of great concern to the Commerce Commiteee and DOT, which is under our jurisdiction. So I am pleased to be here to also welcome the Secretary and the FAA Administrator and others who will tell us of their plans regarding noise abatement, air pollution, and even water pollution as it affects our environment in relation to transportation—air, water, and surface transportation.

(Senator Magnuson's statement follows:)

STATEMENT OF HON. WARREN G. MAGNUSON, A U.S. SENATOR FROM THE STATE OF WASHINGTON, AND CHAIRMAN OF THE SENATE COMMERCE COMMITTEE ON AIR POLLUTION LEGISLATION

Chairman Muskie, we welcome this opportunity to meet in joint hearings once again to pursue our mutual interest in stemming environmental blight.

Today, in considering the transportation aspects of air pollution, we are continuing the joint activity of our two Committees which began with our hearings concerning the search for a low-emission vehicle.

Just last Friday, we reported to the Senate the first concrete product of that activity; the bill (S. 3072) to provide for Federal procurement of low-emission vehicles.

For many years, the primary focus of the Senate Commerce Committee and its antecedent committees was the promotion and stimulation of the Nation's transportation system—a vital concern for a new notion on an untamed continuent. Today we are learning to balance the pursuit of a expanding transportation system with the imperatives of environmental integrity. To a very large extent this is what these hearings are about today.

For example, in considering the imposition of National Aircraft Emissions standards, we are called upon to judge the proper roles of the Department of HEW, which has responsibility for the health of the Nation and the Department of Transportation which has primarily responsibility for the soundness of the Nation's transportation systems.

We look forward to the testimony this morning. Thank you.

Cochairman **Magnuson**. I might say at this time that last Friday Mr. Secretary, we reported to the Senate the first concrete product of this activity in transportation, S. 3072, which provides for the Federal procurment of low emission vehicles which the Department of Transportation is very familiar with. It also involves GSA and the Government. We expect to have Senate action on that bill as soon as we can after the Easter recess. That has been reported to the Senate floor.

This is one of the first concrete breakthroughs I have had in this whole matter of low emission.

As a matter of fact, I think the bill has something like 67 Senate sponsors, so I think it will pass.

Cochairman MUSKIE. I have heard it said, Senator, that when you have that many sponsors the bill is in jeopardy.

Cochairman MAGNUSON. You can never tell. Thank you, Mr. Chairman.

Cochairman MUSKIE. It is a pleasure to be here associated with Senator Magnuson and Senator Hart and Senator Moss and other representatives of the Commerce Committee again. Increasingly, we find ourselves interested with overlapping jurisdiction in this field.

Yesterday, Senator Magnuson, we held hearings on the question of pollution control. One bill is pending before your committee, Senator Hart's subcommittee, introduced by Senator McGovern with Senator Hart. At the same time we were hearing similar legislation which has been referred to this committee. So I expect this association is going to continue.

Senator Randolph has come into the room since we began the hearings. I wonder if Senator Randolph, who is the chairman of the full Committee on Public Works, may wish to say something at this point?

Senator RANDOLPH. Mr. Chairman, Secretary Volpe and FAA Administrator Shaffer are knowledgeable in the matters that they will discuss with us. Rather than take any time, I would like for them to proceed with their testimony.

Chairman MUSKIE. Thank you, Senator Randolph.

It is a pleasure to welcome this morning a neighbor of what was left of Massachusetts when we left, Secretary of Transportation, Secretary Volpe.

Secretary Volpe, it is a pleasure to welcome you this morning. You may proceed in your own way. Will you identify your colleagues for the record?

STATEMENT OF HON. JOHN VOLPE, SECRETARY, DEPARTMENT OF TRANSPORTATION; ACCOMPANIED BY JOHN H. SHAFFER, ADMINISTRATOR, FEDERAL AVIATION ADMINISTRATION; JOHN POWERS, DIRECTOR, OFFICE OF NOISE ABATEMENT, FEDERAL AVIATION ADMINISTRATION; J. THOMAS TIDD, ASSISTANT GENERAL COUNSEL, DEPARTMENT OF TRANSPORTATION; CHARLES FOSTER AND RICHARD STROMBOTNE, OFFICE OF RESEARCH AND TECHNOLOGY, DEPARTMENT OF TRANSPORTATION

Secretary VOLPE. Thank you very much, Senator Muskie. I will be happy to identify the gentlemen who appear with me, today.

Mr. Chairman and members of the joint subcommittee, I am pleased to come before you today. I would like you to meet first, the Federal Aviation Administrator, who is on my right, Jack Shaffer, and to his right John Powers, the Director of the Office of Noise Abatement of the Federal Aviation Administration.

On my left, Tom Tidd, Assistant General Counsel for the Department and to his left is Charles Foster and Dick Strombotne, both from our Office of Research and Technology.

I appreciate this opportunity to appear before you to discuss what President Nixon has described as "our most serious environmental problem"—the pollution of the air we breathe.

Unfortunately, the machines which provide this Nation with unparalleled mobility also contribute a large share of the particles and fumes which pollute its air. In my previous appearances before a joint hearing of your committees on February 4, and in a hearing before the Commerce Committee on January 29, I reviewed the magnitude of this problem and the efforts underway within the Department to cope with it. I will not retrace those steps but I would like to reiterate one point—the determination of the Department of Transportation to assure that transportation is used as a force to enrich life, not to destroy it. For years our safety programs have been directed to this end. Only too recently have we become aware of the hazards created by the pollution of our environment.

Shortly after taking office, I established in the Department an Office of Environment and Urban Systems headed by Assistant Secretary "Dorm" Braman, former mayor of Seattle. He has been given a broad mandate to scrutinize all transportation programs to assure that in the future we anticipate and avoid adverse environmental effects. The human element, in all of its aspects, will get top priority in the planning and building of our Nation's transportation facilities.

I intend to dispel any notions that environmental protection and transportation safety are incompatible goals. When blankets of smog over our cities are so thick they impair visibility from a cockpit, and when rivers are so polluted they catch fire, it is clear to me that the goals are intimately related.

With this background on how we intend to approach the problem of environmental protection, I would like to turn to the legislation before the committee, S. 3229, S. 3466, and S. 3546, bills to amend the Clean Air Act. The Clean Air Act is composed of two major titles—title I deals with air pollution prevention and control in regions and title II with emission standards for motor vehicles. Pursuant to title II, the Secretary of HEW may establish emission standards for any class of new motor vehicles or vehicle engines. The Secretary of HEW may also require manufacturers of designated fuels and fuel additives to supply him with information relative to the additives in the fuel. Title II also authorizes the Secretary of HEW to make grants to State agencies with respect to costs incurred in connection with emission device inspection and testing programs. Before making such grants, HEW must secure from the Department of Transportation a certification that the emission inspection program is consistent with the highway safety inspection program carried out pursuant to the Highway Safety Act of 1966. Since the Department of Transportation is primarily interested in title II of the act, I will limit my comments to the amendments being proposed to that title.

S. 3229 and S. 3466 would amend title II of the Clean Air Act in differing ways. S. 3466, the administration's bill, would amend section

206 to authorize testing of production models of new motor vehicles. Under the existing law, the Secretary of HEW tests only the prototype and, based on that test, issues a certificate for the production model. HEW has found that the production models are not performing as well as the prototypes and that production testing is now necessary. The Department believes this is a sound amendment and would expect to work closely with HEW to assure that testing or inspection of production vehicles for emission control is fully coordinated with any testing or inspection the Department is doing to assure conformance with the motor vehicle safety standards which it issues.

S. 3466 would also amend section 210 of the act, which deals with the registration of fuel additives. The amendment would require registration of all fuels intended for use in transportation of persons or property, and would require manufacturers to furnish such information as is necessary to determine the emissions resulting from the use of the fuel. A new subsection would be added authorizing the Secretary of HEW to establish standards respecting the composition or the chemical or physical properties of any fuel or fuel additive to assure that it will not cause or contribute to emissions which would endanger the public health or impair the performance of emission control devices in use or to be used on motor vehicles or motor vehicle engines.

The Department fully endorses the need to establish standards for transportation fuels and additives. The establishment of fuel standards by HEW should not adversely affect transportation safety. The authority which this legislation would confer on the Secretary of HEW would in no way, of course, affect the continuing responsibility of our Department to regulate aircraft fuels in the interest of safety pursuant to the Federal Aviation Act. To clarify this important matter, we would recommend that the bill be amended to provide that, prior to the issuance of fuel standards by the Secretary of HEW, the Secretary of Transportation shall have found that the resulting fuels meet requirements of aviation safety. This would simply carry out this Department's responsibility already contained in the Federal Aviation Act. Fuel is a critical component in aviation and, given the immediacy of the threat to human life, its safety must be assured in the development of our antipollution measures.

I am concerned with the fuel problem in other areas of transportation safety as well—for example, changes in fuel may also have very significant effects on vessel safety. However, with respect to the other modes of transportation, I believe we can work less formally with HEW in reviewing the safety aspects of fuel standards. We would also expect to work closely with HEW to assure that their fuel standards are based on an adequate assessment of technical feasibility and economic costs.

While S. 3229 would make no amendment with respect to the registration of fuels or the establishment of standards for fuels, it would amend section 202 of title II to authorize the Secretary of HEW to establish emission standards for transportation vehicles and engines. The present section 202 limits the establishment of emission standards to new motor vehicles and new motor vehicle engines. S. 3229 would expand the standard-setting authority to include "any classes of vessels, aircraft, commercial vehicles, new noncommercial vehicles, vessel, commercial vehicle or aircraft engines, or new noncommercial vehicle engines." It provides, however, that regulations with respect to aircraft shall not be made effective until the Secretary of Transportation determines that they would not interfere with the safety of the aircraft.

The question of establishing emission standards for aircraft, pursuant to our existing authority, is now under study within the Department. We would have no objection to the extension of HEW's emission standards authority to the modes of transportation cited in S. 3299, with the exception of aircraft. I understand that in their testimony last week, HEW cited the work underway with the airlines to control smoke emissions and the research underway with respect to other emissions. They concluded that they did not require additional statutory authority at this time. If section 202 is amended to give HEW standard-setting authority over vessels, we would suggest that the certification of vessel engines, and the related functions of inspection and enforcement, be performed by the Department of Transportation rather than HEW. Given the very extensive inspection and certification activity of the Coast Guard with respect to vessel construction and operation, we think it would be extremely unwise to duplicate or divide this function in any respect. As indicated in the above discussion of fuel standards, the Department would expect to work closely with HEW to assure that safety is not compromised in any mode of transportation by the establishment of emission standards.

S. 3229 would amend the Clean Air Act in one other area of interest to the Department—that is, with respect to the development of low-emission vehicles. In its testimony before the committee last week, HEW indicated its support for this concept but stated that new legislation was not required. I would like to add my support to that position. Under existing legislation, such as the Urban Mass Transportation Act, the Department of Transportation is encouraging the development of low-emission vehicles. As I stated in my testimony before the Senate Commerce Committee of January 29, 1970, we have several research and development projects under way to reduce pollution from buses. And in every project for financial assistance to States and local public bodies for the improvement of equipment for use in mass transportation in urban areas, we intend to take full advantage of the opportunity and obligation to assure that the equipment will be designed and used to minimize air pollution. Moreover, as you know, the President announced in his February 10 message that an extensive Federal research and development program in unconventional vehicles would be conducted under the general direction of the Council on Environmental Quality. I think, as the President has indicated, the problem is more, one of marshaling our research efforts than one of insufficient legislative authority.

S. 3229 would also establish within HEW an Office of Noise Abatement and control. Many agencies of Government, including the Department of Transportation, have offices of noise abatement working on this problem. It is a very serious problem which pervades our society. Noise has a multitude of sources leading to many adverse effects. As a member of the Cabinet Committee, I participated in the development of a plan for attacking the noise pollution problem in all of its aspects. The recently established Council on Environmental

Quality now has that plan under review. I believe we should avoid any legislative approaches to further study the problem when we already have a clear notion of the programs required to reduce noise and the organizational structures necessary for carrying them out. As you undoubtedly know, the Department of Transportation has been guiding the deliberations of the interagency aircraft noise abatement program since 1967 when the responsibility was transferred to this new Department from the President's science adviser. In consolidating these aircraft noise and sonic boom activities and welding together more than 130 active participants, the Department rapidly learned the necessity of calling upon all possible contributors from Government and industry.

We concur with the statements submitted to this committee on March 17 by HEW that high priority needs to be given within HEW to the establishment of the possible nonaural physical and mental health problems created by excessive noise exposure. This information will be needed by the departments and agencies presently directing research and regulatory programs to reduce noise levels. I recommend to the committee, and would like to offer for the record, the Federal Council of Science and Technology document "Noise—Sound Without Value" prepared jointly by the Federal agencies concerned with noise. We feel that the plan we have developed within the Cabinet Committee will provide the impetus and the means by which the recommendation embodied in that report can become noise abatement accomplishments.

While on the subject. I would like to review briefly for the committee what the Department is doing in behalf of noise abatement. The Federal Aviation Administration issued a rule, which became effective last December, to provide noise certification of future subsonic jet aircraft. This means that these new aircraft will not be certificated for use until the manufacturer demonstrates that they generate no more noise than the prescribed levels. We are continuing research, with the assistance of NASA, to develop and demonstrate means to further reduce aircraft noise levels.

A notice of proposed rulemaking is being prepared to prohibit sonic booms caused by civilian flights over land areas of the United States. The data clearly show that, within the present state of the art, the supersonic transport aircraft must have restrictions placed upon their operations to properly protect the public from sonic booms. At the same time, we are continuing to search for solutions to the sonic boom problem—solutions which, ultimately, may permit supersonic aircraft to shorten transit times between continental cities without producing sonic booms.

I might add that before the end of next month we will also issue a notice of proposed rulemaking covering noise levels for supersonic aircraft operating on the ground, and in landing and approach patterns. This is a separate issue from the sonic boom but one that we are not overlooking.

Surface transportation noise, while usually not of such high intensity as aircraft noise, is more pervasive—it penetrates all corners of even the most remote residential areas. In particular, we are working to improve our understanding of options available for the abatement of highway noise. Highway siting and design and local enforcement of vehicle maintenance and operation are but a few immediate items being explored. Only through such efforts can the public expect to see an improvement in their acoustic environment. Simply studying how bad the problem is without effecting noise reductions will not improve the quality of life for those people living adjacent to the Nation's more than 3.7 million miles of roads and streets.

In closing, Mr. Chairman. I would like to summarize our position on the legislation before you. We support those amendments to the Clean Air Act which would authorize HEW to:

Conduct emission tests of production models of new motor vehicles;

Register transportation fuels and establish standards for fuels and additives;

Establish emission standards for all transportation vehicles and vessels other than aircraft.

We would recommend an amendment to S. 3466 to require a safety finding by the Secretary of Transportation prior to the issuance of any aircraft fuel standards.

This concludes my prepared statement, Mr. Chairman and members of the joint committee. I shall be happy to answer any questions you may have.

Cochairman MUSKIE. Thank you, Mr. Secretary.

I will ask two or three questions and then yield to my colleagues.

First of all, with respect to existing law on emission standards, we had some discussion last week about whether—existing law gives HEW the authority to require the testing of production vehicles. I see no reason to belabor the point this morning, but I want to reemphasize my conviction that existing law gives the administration the right to test any vehicles that they decide ought to be tested. I was just reading the language again for the record in section 206(a):

> Upon application of the manufacturer, the Secretary shall test or require to be tested in such manner as he deems appropriate any new motor vehicle or new motor vehicle engine submitted by such manufacturer to determine whether such vehicle or engine conforms with the regulations prescribed under section 202 of this title.

Apparently people in HEW interpreted that to mean limiting them to prototype engines. I don't think that is an accurate interpretation of the language but if the Department is not inclined to act, except in clarification legislatively; of course, we consider the legislative clarification. We got into an extensive discussion of that last week. I see no need to pursue it this morning; I just wanted to mention it so our feeling would be clear to you, Mr. Secretary. It is not an important point because we both want the same result.

Secretary VOLPE. Yes; we do.

Cochairman MUSKIE. We want to be able to test whatever vehicles need to be tested. We want to be sure the Administration is sure it has the authority.

On the question of the issuance of fuel standards, at the top of page 4 of your statement, the first complete sentence, you make the point that I would like to inquire about. First of all, I want to be sure I understand coverage of S. 3466 on this point.

Under present law dealing with registration of fuel additives, the law covers not only fuels used for motor vehicles but also fuels used "for the purpose of other than motor vehicles."

As worded, then, it would presumably cover aviation fuels, depending on how you wanted to apply it. But S. 3466, it seems to me, clearly is limited to fuels for motor vehicles.

Is that your understanding, Mr. Secretary?

Secretary VOLPE. It is actually fuel for transportation vehicles, Mr. Chairman.

Cochairman MUSKIE. Let me get this language to make sure. On the bottom of page 6 of S. 3466—let me read it all here:

> The Secretary may, on the basis of information obtained under subsection (c) of this section or any other information available to him, establish standards respecting the composition or the chemical or physical properties of any fuel or fuel additive to assure that such fuel or fuel additive will not cause or contribute to emissions which would endanger the public health or welfare, or impair the performance of any emission control device or system which is in general use or likely to be in general use (on any motor vehicle or motor vehice engine subject to this title) for the purpose of preventing or controlling motor emissions from such vehicle or engine.

Now that language appears limited to fuels used in motor vehicles or motor vehicle engines. Was it the intent that it be broader than that?

Secretary VOLPE. Yes, Mr. Chairman. As our counsel indicates to me. he believes—you started reading on page line 15(b). "The Secretary may, on the basis of information", and so forth, and the first part of that under (c):

> * * * establish standards respecting the composition of the chemical or physical properties of any fuel or fuel additive to assure that such fuel or fuel additive will not cause or contribute to emission which would endanger the public health or welfare * * *

He has interpreted that to apply to all transportation fuels whereas after the comma then you add "or impair the performance of any emission control device or system which is in general use or likely to be in general use (on any motor vehicle or motor vehicle engine subject to this title)." In other words, my counsel tells me that under the first part of (c) applies to all transportation fuel whereas when you come to the words "or impair the performance of any emission control device," that that would apply only to the motor vehicle.

Cochairman MUSKIE. Let me ask you this: It is a long, involved sentence but it seems to me that both subsection (b) and subsection (c). if you take out the modifying language in the middle of the sentence. seem to say this: "For the purpose of establishing standards the Secretary may require the manufacturer of any fuel, or fuel additive, to furnish such information as is reasonable and necessary." Then you drop down to line 22, "for the purpose of preventing or controlling motor vehicle emission."

Secretary VOLPE. Mr. Chairman, I would agree with you that, although my counsel says this would give us the authority for all transportation fuels, it could be written a little more clearly. We would have no objection to the committee rewriting that paragraph to indicate what I have just indicated, and that is that it covers all transportation fuels.

Cochairman MUSKIE. That is my only point. As long as that is clear. we have no difficulty.

Since the intent is to cover not only motor vehicle fuels but aviation fuels, I would like to turn to the top on page 4 of your statement:

We would recommend that the bill be amended to provide that, prior to the issuance of fuel standards by the Secretary of HEW, the Secretary of Transportation shall have found that the resulting fuels meet requirements of aviation safety.

The question I want to ask is this: Some additives are related to the need for enhancing the power performance or characteristics of engines. Lead, I gather, is one such.

Secretary Volpe. Not in jet aviation fuel, I don't believe.

Cochairman Muskie. Let me put my question and then you can have your experts apply it to aviation and motor vehicle fuel.

Secretary Volpe. Yes.

Cochairman Muskie. At least the motor vehicle manufacturers consider power as safety.

Secretary Volpe. Yes: motor vehicle, that is correct.

Cochairman Muskie. I would like to know what relationship there is between this observation in your statement and the possibilities of eliminating lead, especially for motor vehicle fuels. Is it likely to inhibit or delay the elimination of lead from fuels because of a safety factor related to power?

Secretary Volpe. If you are talking about the motor vehicle alone, Mr. Chairman, there is no problem. We can say that the elimination of the lead definitely reduces pollution. We know what the manufacturers are going to do. They have got to reduce the compression ratio, we have got to reduce the octane rating in order to use the nonleaded gasoline properly. It can be used today and it does reduce the hydrocarbons even without these changes in engines. But insofar as the aviation side of it is concerned, as I understand it that is a pretty clear fuel but we better let our Federal Aviation Administrator clarify that point.

Cochairman Muskie. Before you do, I want to be sure I understand whether the proposed amendment might be interpreted to delay any improvement in fuels—from the pollution point of view—that might have the effect of reducing the power characteristics of an engine: in other words, its power, for the purpose of this amendment. I'm still talking about motor vehicles.

Secretary Volpe. Mr. Chairman, I have no inhibitions at all about reducing power on the automobile. If taking lead out and reducing pollution takes a little power out, so be it. I don't think we need all that power.

Cochairman Muskie. Fine. Now if we could have the answer on aviation fuels.

Secretary Volpe. Mr. Shaffer.

Mr. Shaffer. As you know, Mr. Chairman, the bulk of aviation fuel today, that is, the big consumer of aviation fuel is the jet engine and it is unleaded. It is basically kerosene. It has no additives at all, and the major byproduct of combustion in a jet engine is hydrocarbon. In the case of aviation gasoline, used in reciprocating aircraft engines, the principal aviation safety concern relates to such matters as flammability, flash point, and the like. Because of the design of reciprocating aircraft engines, preignition is not as much a problem as these other fuel properties. As a consequence, most of the aviation gasoline used today contains very little tetraethyl lead. Therefore, lead is not a significant pollutant in aviation fuel. It is used primarily to eliminate preignition in motor vehicles, which have an entirely different set of engine operation problems from those of the airplane. Motor vehicle engines must be operated at far cooler temperatures than the reciprocating aircraft engine. Therefore, the problems of preignition—and the need for tetraethyl lead—are much greater in the high performance motor vehicle engine than in the aircraft engine.

Cochairman Muskie. Senator Magnuson?

Cochairman Magnuson. I want to agree with the Secretary and the Administrator that I do think you have to be very careful when you start talking about aviation standards on fuel as it relates to safety. The HEW naturally does not have—at least they don't have now—the expertise to do that and there should be close liaison between the two agencies as to how to go about defining these standards.

Now I want to ask the Administrator this: There is no problem, I understand, from what aerodynamic and aviation engineers say to practically eliminate all pollution in the air from an airplane. Is there?

Mr. Shaffer. When you say "all pollution"——

Cochairman Magnuson. I mean to reduce it to such a minimum that it would not be a problem.

Mr. Shaffer. This is certainly our intent. As you know, the newer engines and the newer airplanes are virtually smoke free and very much quieter. The JT9D jet engine, which powers the Boeing 747 produces about half the noise of the older JT3D.

Cochairman Magnuson. The point is we are trying to get as far as technology will take us in reducing pollution, not only noise but also air pollution. You can do it easier with airplane engines than you can with surface transportation. This is the point.

Secretary Volpe. That is correct.

Mr. Shaffer. I would only make one suggestion, Senator Magnuson. Your choice of words was "gradual." I think considering the technological problems involved, we are rapidly reducing both smoke and noise pollution in aviation.

Cochairman Magnuson. I think we have shown a great deal of improvement just in the last 2 or 3 years in this field.

Now what about general aviation, what is the problem there? The small plane?

Mr. Shaffer. Similarly, the major——

Cochairman Magnuson. You might put in the record, I think the committee members would like to know; it is startling to me to hear of the growth of general aviation as compared to commercial aviation, the number of airplanes in the air. It is almost fantastic and the number is increasing all the time.

Mr. Shaffer. We will put it in the record. The Secretary indicates the current level is 133,000 general aviation airplanes compared to 2,700 civil aviation.

Cochairman Magnuson. 2,700 commercial airplanes as against 133,000 general aviation aircraft. That is quite a spread.

Mr. Shaffer. And our forecasts indicate the spread will become even greater.

Cochairman Magnuson. Some of the small ones make more noise than the big ones, it has been my understanding.

Mr. Shaffer. One of the principal sources of noise.

Cochairman MAGNUSON. They certainly make noise, they fly over my house all the time, but I don't mind it.

Secretary VOLPE. If you lived in the Watergate, Senator, if I could just say so, you probably would mind it.

Cochairman MAGNUSON. Now another thing, because I do have to participate in HEW appropriations and I have not been very successful with it this past year, and also in DOT appropriations, I would like to know if you have set up an office of noise abatement in DOT?

Secretary VOLPE. Yes, sir.

Cochairman MAGNUSON. How much money are you asking for that, do you recall, in the 1971 budget?

Secretary VOLPE. $1 million.

Cochairman MAGNUSON. $1 million. Now that would have to be what we call farmed out, would it not?

Secretary VOLPE. This is primarily a noise abatement research conducted within our own office.

Cochairman MAGNUSON. You take advantage of NASA in this, don't you?

Secretary VOLPE. I beg your pardon.

Cochairman MAGNUSON. Don't you farm out some to NASA?

Secretary VOLPE. NASA has been working with us very, very closely.

Cochairman MAGNUSON. They have the people and the technique and we give a lot of money to their big testing facility center down in Virginia. What is bothering me about this whole matter is—and I don't exclude the Senate from this, or the House—everybody is getting into the environmental business nowadays and all the committes are involved and all the Administrations are involved and even the Department of Justice is getting involved in environment in some way.

Now I don't want to see it spread out so much. I want to try to get some coordination which I think Senator Muskie's bill provides, so that we just don't all do a lot of little things rather than zero in on the big things. When you talk about noise, this is a purely technological, scientific endeavor that someone has to get at. We don't need any more studies. You can study noise level but everybody knows it is noisy down at 42d and Broadway in New York. So what are you going to do about it?

Now the Government is the biggest purchaser of motor vehicles and, strangely, I was surprised to find that we purchased twice as many buses and trucks as we do passenger cars, and they are among the worst polluters of the atmosphere. So I think the Government can make a start there, and I hope DOT will get right into this because the automobile is the biggest villian in this whole field, there is no question about that.

Secretary VOLPE. Senator, I can assure you that having sat in on the Cabinet Committee on Noise Abatement and having spent a good deal of time on this subject, and our Department of course has had this responsibility since 1967 as far as aircraft noise abatement is concerned, that we are fully aware of the possibilities of overlap and duplication. We just submitted this report to the Cabinet Committee on Environment about 2 weeks ago. The Council on Environmental Quality is looking at it right now and I assume very shortly we will have an overall plan here so that no agency will be duplicating the efforts of someone else.

Cochairman Magnuson. Fine, because otherwise we won't be accomplishing as much as we should.

Secretary Volpe. Right.

Cochairman Magnuson. You have your place in this problem and are looking right down the line at it.

Secretary Volpe. Right.

Cochairman Magnuson. When you talk about vehicles and fuel, there is a combination of mechanical devices plus nonleaded fuel. Those mechanical devices, of which there are several, can be made mandatory, too. Some States do that now, don't they?

Secretary Volpe. Yes. California is the leader in this field. I can assure you that during the last 3 or 4 months alone I personally have looked at what is being done for the devices on the new vehicles and not only in Detroit. I have looked at three different devices that are being proposed for present vehicles, vehicles that are of the vintage of 1966 or earlier. These could be applied to vehicles presently in use at a cost, not of $300 or $400 as envisoned as recently as only 6 or 8 months ago, but for less than $50.

Cochairman Magnuson. This may be an unfair question: Has anyone down at DOT issued any rules about motorcycles?

Secretary Volpe. Our National Highway Safety Bureau would like to issue a standard on at least the helmet that must be worn by——

Cochairman Magnuson. I am talking about noise. I think you had better do that. They can make more noise than 20 cars put together.

Secretary Volpe. Mr. Chairman, I heard a film on noise just about 2 weeks ago and it wound up——

Cochairman Magnuson. This can go to the manufacturer and the importer.

Secretary Volpe. That is correct. It involves both.

Cochairman Magnuson. Thank you, Mr. Chairman.

I want to say that I hope that you people—and I know you want to do this—could work out the differences between S. 3466 and S. 3229. Naturally I think there ought to be emission standards on all vehicles, and aircraft.

Now what standard do you have for diesel?

Secretary Volpe. For aircraft?

Cochairman Magnuson. I don't know, I am not familiar—are there any standards on diesel fuels? Is there lead in diesel fuel?

Secretary Volpe. Just a minute, we will ask the technical person on that.

Dick, can you answer that?

Mr. Strombotne. Yes; the Department of Health, Education, and Welfare has issued standards on diesel emission, and the opacity of the exhaust is controlled at 20 percent during normal operations and 40 percent during lugging operations. Diesel fuel normally is not leaded.

Cochairman Magnuson. It normally is not leaded?

Mr. Strombotne. No.

Cochairman Magnuson. It seems worse, but it is not as noxious as some fuels that do not smell as bad. Isn't that correct?

Mr. STROMBOTNE. Some of its emissions are better than emissions of gasoline engines. Smoke from a poorly maintained diesel is certainly bad, I agree with you.

Cochairman MAGNUSON. Now you suggest that this responsibility that we are talking about here in the field of transportation as it relates to HEW and DOT need not necessarily be divided, but be parallel, work together. Is that about it?

Secretary VOLPE. This is just about the way we would like to see it done, sir.

Cochairman MAGNUSON. Senator Cooper.

Senator COOPER. I have read your statement and you have given a great deal of thought to this problem, such as in the area of the internal combustion engine.

I like the idea of carrying the inspection to the production line, to the finished product.

I want to ask you this question: Assuming that the automobile with appropriate devices meets HEW's standards as it comes off the production line, and is sold, what about maintenance of that device? Do you consider that the devices which they approve are well enough designed to be effective for a period of years?

Secretary VOLPE. Senator, before these are approved for use HEW requires that they be tested from 25,000 to 50,000 miles to be sure they will do the job. Otherwise, it is quite possible that, as you indicate, a device might do the job for 100 or 200 miles and then fail. So the testing would carry it to levels of as far as 50,000 miles, which is a sufficient test to indicate that the device is satisfactory.

Senator COOPER. What about the human element, the operator. Will his skill or lack of skill have any effect on the devices?

Secretary VOLPE. Yes. The success depends on the type of device. Some devices have no moving parts and in such situations there is not much the operator can do that would in any way harm the device.

Senator COOPER. Is there any attendant program—although it would be a very difficult one of inspecting, perhaps it would have to be at the State level—of automobile inspection to determine whether or not they are properly maintained, so the device is effective? Do you have any views on that?

Secretary VOLPE. This is a combination of effort that has not really been entirely resolved between HEW and the DOT as to who would effectively carry out that operation.

My own views are that we should not have duplication of effort here, and that one or the other of the organizations ought to be given the responsibility.

Senator COOPER. Is it possible that your program of continuing inspection of the devices could be combined with the highway safety program, which I understand is undergoing study in the Department?

Secretary VOLPE. My own personal opinion, and this is not an administration opinion but my own personal opinion, is that it would probably be less costly if this inspection were done at the same time that the safety inspection of that vehicle were conducted.

Senator COOPER. I think that is all, Mr. Chairman, at this time.

Cochairman MAGNUSON. Senator Hart.

Senator HART. Mr. Secretary, on this business of coordination with HEW, you perhaps have other studies on noise abatement. Why isn't the logical place to fix that responsibility in the Council on Environmental Quality and let them determine who will do the work?

Secretary VOLPE. This is exactly what has happened, Senator. I, as a member of this task force, together with Secretary Stans, who is Secretary of this task force, with two or three other Cabinet members and our staffs, worked for 2 or 3 months to develop the material that was largely already available. We brought that up to date and indicated all the various facets in Government that are involved, plus industry, and then made recommendations to the Cabinet Committee on Environment because we made it before the Environmental Quality Council was established. With the establishment of the Environmental Council, the Council, instead of the Cabinet Committee, will act on the recommendations as one of its first orders of business. We are now awaiting instructions from the Council as to how we proceed.

Senator HART. Earlier you made the comment that you had passed it on and you were waiting. I wondered if we were to understand that there was an agreement that the Council would write the ticket, it would in a sense allocate the areas of responsibility, and the nature of the studies among the several agencies.

Secretary VOLPE. I would say that it will write the ticket based on the President's decision earlier to ask the Environmental Quality Council to assume coordination responsibility for the nonconventional engines. I assume from that that he desires the Environmental Quality Council to do likewise in this area. They can agree or disagree with the report and allocate to each of the departments involved the particular avenues that they wish them to take.

Senator HART. I think it would be desirable.

Cochairman MAGNUSON. Would the Senator yield?

Of course if that were done, and they laid out the areas of special responsibility, naturally the President would adjust his budget in that direction.

Secretary VOLPE. Certainly. It would be coordination at the budget level very definitely, Senator.

Senator HART. The administration bill I think does not explicitly set up a noise abatement office. Am I correct on that?

Secretary VOLPE. In the HEW, yes; it does not.

Senator HART. In the HEW, yes.

Secretary VOLPE. There are other offices of noise abatement.

Senator HART. You will notice that what S. 3229 and S. 3546 suggest is that the Secretary of the Department establish this office and it shall investigate and study noise and its effect to determine what its effects are at various levels. This is section 202(a) on psychological effects on humans and on wildlife and so on.

Secretary VOLPE. Yes.

Senator HART. A lot of study about the effect of noise but nothing is said about studying technology to eliminate noise, to cancel noise. Isn't that really what we are trying to do, not study its effect but get rid of it?

Secretary VOLPE. Yes; Senator, and we are working at that right now. NASA is developing quiet engines.

We also have contracts in this area. For example we have a grant with the University of Southern California which is on jet noise suppression—specifically to develop ways and means of eliminating noise not just trying to see what noise does to life and so forth. I don't want to hear that noise in future years and the shorter those years the better because then we won't have to worry about the effect on life and health because we will have eliminated it. At least that is the aim I have and we are working toward that end insofar as the authority that we have.

Senator HART. All right.

Now this next question in a sense bears on the same combination. You tell us, on the car that you develop, that your low-emission vehicle development is one of marshaling our research effort.

You have a prototype safety car. Is that going to be a low-emmission vehicle? Do you have the thing in combination there?

Secretary VOLPE. We have requested bids on this, Senator. In the specifications we will have standards set that will at least meet the 1973 standards if not the 1975 standards. So that it will in essence be a combination of standards, both the safety vehicle as well as low emission. However, the primary purpose, as designed by the Congress, is to develop the most safe vehicle that can be developed.

Senator HART. But unless low emission adversely affects safety you can do both with the same vehicle?

Secretary VOLPE. That is correct, Senator, and we hope to.

Senator HART. And low emission does not affect safety. Is that what you were telling Senator Muskie?

Secretary VOLPE. That is correct, Senator, insofar as the car is concerned we don't see that affecting safety. It would affect power but I am not particularly interested in power for a 100-mile-an-hour car.

Cochairman MAGNUSON. The Senator from Michigan and I spent long days and weeks on the auto safety bill, which is now law, which you are familiar with and even he, who is much more privy to the manufacturers than I am——

Senator HART. I would have to define that.

Secretary VOLPE. I do not understand that.

Cochairman MAGNUSON. I could never get satisfactory answers to why you make an automobile that could go 110 miles an hour where there is no place in the United States that you can travel that fast, really. I never could get an answer. So when you talk about power, the statement you made was a good one; if they have to sacrifice that, so be it.

Secretary VOLPE. I made it a little stronger than that before the National Association of Retail Automobile Dealers.

Senator HART. I wonder if my chairman would agree we got an answer. The problem was not that we received no answer; it was rather that the answers we received were devoid of reason.

If we develop a standard for pollution elimination that requires the removal of lead, I take it you are attempting to see how far we can go in that direction. This might permit the automobile manufacturer to bring the emission level in the internal combustion engine down to acceptable standards.

Secretary VOLPE. That is the belief of many, although 6 months ago there were a great many who did not subscribe to that theory and I was one of those. I believe from what I have seen in the last month or month and a half, particularly, although I would not bet all the tea in China, I certainly would say that there is a reasonable chance that the internal combustion engine can be cleaned up sufficiently to allow its use at very, very minimum levels of pollution.

Senator HART. All right. If we accept that as a real possibility then don't you agree that we have to be alerted immediately to the fact that we would have to modify the existing engine to bring that level down to an acceptable minimum. It could complicate the maintenance problem to the point where it would require not a long periodic tuning but very frequent repairs. While nobody quarrels with the desirability of devising methods that will permit the continued production and use of internal combustion engines, we have to recognize a potential consumer problem resulting from the maintenance cost of any such device and we have to be sure that we don't get ourselves down that blind alley, too.

Secretary VOLPE. Senator, I have seen, as I indicated earlier, three devices for present automobiles, and I know what the automobile manufacturers are utilizing for the new vehicles. At least one of the devices proposed for use on present automobiles has no moving parts and would require absolutely no maintenance. I would assume that, if research has produced this type of device for our present automobiles, you ought to be able to get out of the automobile industry a similar device for new automobiles that would require no maintenance, or practically no maintenance.

Senator HART. So you would agree that there is a responsibility on the part of the Government and your Department to insure that fuel standard levels if dropped down do not encourage the development of low emissions add-ons which themselves create an additional problem?

Secretary VOLPE. It has to be a balance, Senator, and I certainly think we have to be sure to keep our eye on that ball, too.

Senator HART. Thank you very much.

Thank you, Mr. Chairman.

Cochairman MAGNUSON. Senator Dole.

Senator DOLE. Very briefly, I know there are other witnesses.

Mr. Secretary, earlier this morning we had a very fine statement by Congressman Kleppe from North Dakota. The testimony related to the advantages of combining alcohol refined from grain with gasoline to make a clean burning motor vehicle fuel. I understand this has been called to the attention of your Department and there has been an interest expressed, and some research in this area. Of course, we have a selfish interest coming from the grain-producing States of North Dakota and Kansas, but we would emphasize again, the importance of additional research in this area since it may assist in the control of auto emissions.

There are, of coourse, pressures from others in the fuel-making business. The pressures are not the same as they were years ago because now we are talking about nonleaded gasoline and even the experts say it will take some time before lead can be eliminated.

So, on behalf of Congressman Kleppe and others who have indicated an interest, we would hope that there will be serious consideration given by your Department to this very important field.

Secretary VOLPE. Senator Dole, you can rest assured that we will give consideration to every suggestion. Some of them wind up going in the wastebasket, or should, while others have genuine possibilities. We explore all of them. I don't know what the particular status of this one is. As a matter of fact, while pumping my bicycle this morning in my bedroom watching a TV program—this is not a joke—I found that someone in England has discovered that chicken manure, of all things, may be able to be used as a fuel instead of gasoline or other products.

Senator Dole. That may be another possibility, but we would like to have you explore ours first.

Secretary Volpe. I think it probably has more potential, Senator.

Senator Dole. Thank you, Mr. Secretary.

Cochairman Magnuson. Senator Randolph.

Senator Randolph. Secretary Volpe, in your statement—I read these words:

> We would have no objection to the extension of HEW's emission standards authority to the modes of transportation cited in S. 3299, with the exception of aircraft.

Mr. Secretary, do you support or do you oppose statutory authority to supplement the voluntary aircraft smoke emission agreement?

Secretary Volpe. We have supported the idea that some of these things can be done through voluntary effort.

Senator Randolph. And they are being done?

Secretary Volpe. And they are being done as was proven a few weeks ago when Secretary Finch and I sat down with airline representatives and obtained their agreement to retrofit the present fleet of planes that produces the largest amount or smoke.

Instead of being completed in 1974, as had been originally suggested, they agreed to complete this retrofit operation by 1972.

Senator Randolph. Do you believe that it can be done to reduce effectively aircraft emissions?

Secretary Volpe. On a voluntary basis?

Senator Randolph. Yes.

Secretary Volpe. I think eventually you are going to have to have Government standards. I would like to think you can do it voluntarily alone but I think eventually you are going to have to have some standards. That will be developed under a statutory basis.

Senator Randolph. I see.

Secretary Volpe. In the case of the Federal Aviation Administration, if I may add. Senator, we have already acted because we believe we have the authority. I think one or two people have disputed that but our counsel tells us that we do have the authority. We have prepared an advance notice of proposed rulemaking on aircraft engine emissions which will go out for comment soon.

Senator Randolph. Perhaps Administrator Shaffer would like to comment. There are more reasons, perhaps, than we know as to why you think we cannot do it all on the voluntary basis. Mr. Shaffer, is there a resistance or is there a reluctance by the scheduled air carriers, rather than general aviation, to move into these agreements, voluntary in nature, which Secretary Volpe has mentioned?

Mr. Shaffer. No, sir. Senator Randolph, all of the air carriers have agreed to this voluntary program and as the Secretary has indicated, the program will be substantially completed by 1972. When I say substantially completed, I don't mean that there is going to be a big hangover into later periods, it is simply that we are hoping to accomplish this consistent with the availability of these regular retrofit parts and at the time that the engines are normally overhauled. We really don't want to impose too tough a program on them. When I say "too tough," I don't mean that we don't want to see them do it, we simply want to see them do it consistent with their economic ability.

Substantially completed by 1972 means that 562 of the total of 650 JT80 engines of United Airlines, for example, will be retrofitted with the smokeless combustion cars by that date. Most, if not all, of the air carriers will comply with the retrofit schedule. We will soon begin to see a noticeable reduction in smoke around all of our major airports.

The Boeing 727 and 737 and the DC–9 are the principal contributors to the smoke problem, and most of them will soon enter the retrofit program. These are the airplanes operating in the greatest number at our busiest airports.

Senator RANDOLPH. The reason I phrased my question as stated is because there have been charges against the air transport industry of failure to appreciate its problems in the depth that it should. I have felt this in talking with airline officials. I wanted to hear from you, Mr. Secretary, and from the Administrator of the Federal Aviation Administration your experience in working with this segment of the air transportaion industry.

Secretary VOLPE. Senator Randolph, there are those that say that Secretary Finch and I must have used an awfully heavy hammer to get them to consent to this agreement. I didn't use a hammer at all, and neither did Secretary Finch. We had a very thorough discussion of the problem. We had done a little homework before we arrived at the meeting, of course, and knew what could be done, and what could not be done. We proposed a 1972 date and, except for one comment, on the part of one of the airline officials present who thought maybe 1973 ought to be the date, the rest of them all said no, we will do it in 1972, and 1972 it was.

No threats or anything else like that were necessary to bring about this agreement.

Senator RANDOLPH. Thank you very much for exploring that subject with me.

You say, Mr. Secretary, "Highway siting and design and local enforcement of vehicle maintenance and operation are but a few immediate items being explored."

Now I know that your Department is taking steps in regard to highway location and design as you attempt to reduce the noise created by the use of buses and trucks and automobiles on our highways. I realize this. I wonder if you could explain a little more definitively what programs are being carried forward?

Secretary VOLPE. Well, in the development of——

Senator RANDOLPH. Let's say landscaping for a moment.

Secretary VOLPE. There are areas in my own experience, for instance, as Commissioner of Public Works where we had an expressway that was passing through an area that was relatively close to a school. By planting a screen of trees there, the noise from the roadway was substantially reduced as far as that school was concerned. We had several experiences of that type.

In the planting that one does on some of these embankments, a similar opportunity is available. More and more we are giving greater emphasis to the human environment, from noise all the way to rehabilitation of homes and all the other factors that we take into consideration.

Senator RANDOLPH. Yes, and Mr. Secretary, you were very helpful in our development of the 1968 Federal Highway Act in reference to these matters that concern the problems of relocation and compensation. Your leadership through the years meant very much in these fields.

The Japanese are building highways above their structures, their buildings. Would you comment on any experience that you may have had with any study, if you have made a study of highways constructed above buildings in that country?

Secretary VOLPE. I do not have any knowledge in any depth on that subject. I did go to Japan and looked at one facet of their transportation system, which is of such great interest to all of us; namely, the bullet train. While I do not know much about Japanese experience, we are working here in the United States with new highway design concepts, providing for highways in some cases above shopping malls, and then with housing on top of the highway. That way, we can replace the housing that is taken as we go along. Only after we constructed sufficient housing adjacent to or as close as possible to the highway, do we go on with the second part of the project.

In all of this we are utilizing scenic design, planting trees, and so forth, to enhance these developments in such a way that they don't just look like a massive pile of concrete, and will add to the area rather than subtract from it.

Senator RANDOLPH. Secretary Volpe, what sort of noise level criteria are you using? Do you have it spelled out?

Secretary VOLPE. I don't have that at my fingertips but I think it is on the order of 80, 85 decibels. Does that sound about right?

Mr. FOSTER. We are looking at how much the various factors would change the noise. Our criteria is as low as possible, depending on the various situations to be considered, including the noise of the vehicles themselves. We are studying alternatives to determine what are the changes in noise level that would result from implementation of these various factors.

Senator RANDOLPH. Mr. Secretary, we have completed and have in being two-thirds or more of the 42,500 miles of interstate highways authorized to be constructed.

Secretary VOLPE. That is correct, sir.

Senator RANDOLPH. We have had about 176,000 miles of highways in congested areas in cities where there are very severe problems related to the relocation of businesses and housing.

Secretary VOLPE. I am sure you will be happy to note, Senator, that has been reduced to 124,000.

Senator RANDOLPH. 124,000?

Secretary VOLPE. Yes; I wish it were zero.

Senator RANDOLPH. We are discussing a small percentage of the total highway mileage, but these problems are very urgent, aren't they?

Secretary VOLPE. Yes.

Senator RANDOLPH. We had one in Charleston, W. Va., of very great concern.

I want to commend you, Mr. Secretary, for following through with Secretary Romney, as you and others of the administration have done in thinking in terms of housing being available before demolition and before moving in with cement or asphalt too build roads. Persons in business or in residence must not be forced to move and then hunt something. We have planned so that these persons can be helped and aided, as you know.

Secretary VOLPE. Yes.

Senator RANDOLPH. I think this is a significant step that the administration has taken. We have pioneered in our Public Works Subcommittee on Roads, and in the Public Works Committee, in working out provisions of law to help in this matter.

Secretary VOLPE. And the Federal Highway Act, as a matter of fact, pioneered in this area.

Senator RANDOLPH. That is correct. It was the first law in which it was done, and it was necessary to do it.

You accepted the mandate of Congress and you are moving forward in this area. I hope you can help to settle the Charleston, W. Va., matter very quickly.

Secretary VOLPE. I have to settle one in Boston, too, Senator.

Senator RANDOLPH. Mr. Secretary, I call your attention to an article with pictures that I read in the Sunday, March 22, Washington Post. I find here a picture of Louis J. Fuller and the headlines are that "The Los Angeles smog control boss stands near air pollution monitoring equipment on the roof of his headquarters as he announces that he plans to retire because there is nothing much left for him to do in the city. Los Angeles air is the cleanest since 1954 and is getting cleaner all the time."

This is the first positive results story that I have seen in the last few weeks or months; it is usually a discussion of a condition that is becoming worse.

Now if, as the story indicates, it is true that Mr. Fuller has been "cleaned out," why, I wonder if it is because there has been a reduction of the problem of emissions from the engines in the automobiles which have created perhaps 70, 80, 90 percent of air pollution in that sprawling area of Los Angeles County. Is that right?

Secretary VOLPE. It runs up from 55 percent to 95 percent. Los Angeles is one of those cities in the higher percentages. I would say it is in the order of 70 to 80 percent.

Senator RANDOLPH. Now he indicates that "working here for some 15 years, this progress has been made." Would you indicate whether or not you believe that what Mr. Fuller says is correct, that there is constantly cleaner air in Los Angeles, and can it be attributed to the programs of research and pilot projects, as well as the equipment that was actually installed on the automobile?

Secretary VOLPE. I would say first, Senator, if I may, that the condition is much worse today than it was 15 years ago.

Senator RANDOLPH. In Los Angeles?

Secretary VOLPE. In Los Angeles. But I would say that in the last year or two, particularly as a result of many of the steps that have been taken, you start to see a gradual improvement. This will not be an improvement that will be visible to the ordinary person without the mechanism or mechanisms that Mr. Fuller has available to him to do some measuring. I would say that from a helicopter as I viewed it last summer, and I had not seen it for some time, it looked worse to me than on the previous visit I had made, but that was some years ago.

I can appreciate that as a result of what has been done on a nationwide basis, and what has been done more particularly in the State of California itself, that if he quotes actual statistics from records which are measurable, then I certainly would not quarrel with him.

Senator RANDOLPH. Mr. Secretary, our staff on the Subcommittee on Air and Water Pollution is going to check this out. I am going to request an explanation and find out just exactly what the droppage has been in the smog level but I thought that perhaps you would have some comment with reference to the reduction in automobile emissions causing a cleaner air condition in that city.

I have another question for you, Mr. Secretary.

How many cars are now operating on the highway and streets in America?

Secretary VOLPE. About 100 million.

Senator RANDOLPH. 100 million.

What do you estimate to be the number of cars to be operating 5 years from now? 10 years from now? Do you have any projections?

Secretary VOLPE. Yes, we have projections. In the next decade there will be at least a 50-percent increase. as has been forecast, and in the next 5 years it probably is about half of that, a 25- or 30-percent increase.

Senator RANDOLPH. Then you say 150 million to 175 million automobiles will be operating within the next, let's say 10 or 15 years?

Secretary VOLPE. Yes. I will qualify that only with this proviso, Senator. If the American public should decide that riding a subway—a good, clean, efficient, courteous service on a subway or a bus—is not a reduction in status, then I think we may not see quite that many automobiles. Also, if the House does what the Senate has already done—for which I congratulate them—pass the public or mass transportation bill, then I believe that this rate of growth may be slowed some. I don't see how you will slow it entirely and I don't know that it is essential or necessary to do so when you realize that there is going to be another 100 million people in our Nation by the end of this century.

Senator RANDOLPH. You speak rather hopefully of comfortable and clean subway transportation. Have you been in the subways of New York lately?

Secretary VOLPE. Yes, but not all of them. I was in one of the new cars on the New York subway system and it was a very pleasant experience, air-conditioned and so forth. I was not in the older cars. They didn't take me to the older cars.

Senator RANDOLPH. A series of articles, at least two that I have noted in the New York Times, indicates the deterioration of the subway system in New York City and the vast sums of money that would be necessary to bring the subway operations up to desirable standards. I am sure that we can make progress in all forms of transport, and I know that you are attempting to provide the leadership for a balanced transport program.

Mr. Administrator, would you comment on the number of aircraft? I know we have had certifications here today but would you give the total number of aircraft that are now flying in our skies?

Mr. SHAFFER. We have 133,000 active general aviation airplanes and about 2,700 active air carrier airplanes at the present time. In this decade ahead the general aviation fleet will virtually double. There won't be that kind of growth in the air carrier fleet. There we will only go from about 2,600 to 3,800 in the next decade. This lower growth rate is explained by the fact that we are entering the era of wide body airplanes so that many more seats will be available in the new airplanes. The seat growth will be very substantial. Our forecasts indicate that there may be as many as two and a half million people airborne over the United States at a given instance by 1980.

Senator RANDOLPH. Mr. Secretary, there are estimated to be 150 million cars operating in 10 years on our highway system and there are to be 250,000 aircraft operating in our airways systems, as you and Mr. Shaffer have testified. This seems to be an overriding reason why you, Mr. Secretary, and the Administrator, and all those in Government who are charged with the responsibility for transportation, must continue to give a large portion of your time and talent to working out these problems. Our committees here in Congress are attempting to work further the progress toward solutions, too. If we do not do it there will be not only a breakdown of our over burdened transportation system which has strengthened our economy and brought mobility to our people with movement of persons and products.

I want to commend you. I want to appeal to you to do more than you have done. Certainly I charge myself, and the Members of the Congress and this committee and the other committees that deal with these subjects, to set a priority which we have not yet attached to these problems and the solutions for enhancement of the quality of our environment.

Do you agree with this, sir?

Secretary VOLPE. I could not agree with you more, Senator.

As I said a little earlier, what we hope to do is not only provide transportation just to move people and goods, but to provide transportation in such a way that enriches our lives rather than help to destroy them.

Senator RANDOLPH (presiding). Thank you very much.

Senator Baker, do you have questions of the witnesses at this time?

Senator BAKER. I won't take long, Mr. Chairman, nor will I impose unduly on the Secretary or the Administrator. They have been through a long morning.

Before I do start I would like to ask unanimous consent to insert a statement by Mr. Dwight L. Miller, the Assistant Director of the Northern Regional Research.

Senator RANDOLPH. Yes, the material will be included.

(Mr. Miller's prepared statement follows:)

STATEMENT OF DWIGHT B. MILLER, ASSISTANT DIRECTOR, NORTHERN REGIONAL RESEARCH LABORATORY, AGRICULTURAL RESEARCH SERVICE, U.S. DEPARTMENT OF AGRICULTURE, PEORIA, ILL.

Mr. Chairman, I am Dwight L. Miller, Assistant Director, Northern Regional Research Laboratory of the Agricultural Research Service, U.S. Department of Agriculture, in Peoria, Illinois. I am a Chemical Engineering graduate of the University of Illinois, and had over 20 years experience in the fermentation and chemical industries before joining the Department of Agriculture 12 years ago. Our division conducts utilization research on corn, wheat, grain, sorghum and other grains.

In the past two or three years we have had increasing interest and inquiries concerning up-to-date information on the production of ethyl alcohol from cereal grains and its use in motor fuels. About a year ago I was requested to bring together the studies and developments and prepare a report on "Industrial Alcohol from Wheat," for presentation at the Sixth National Wheat Utilization Research Conference, Oakland, California, Nov. 5–7, 1969.

Since I presented the report in November, there has (recently) been fuller recognition of motor fuel as an air pollutant, and the overabundant supply of cereal grains has resulted in greatly renewed interest in the whole subject of alcohol's use in motor fuels.

I will present the highlights of my research report and then be glad to answer any questions relating to the technical processes of producing alcohol from grain and some of the aspects of utilization of that alcohol in a motor fuel mixture.

Ethyl alcohol in the United States is produced both by fermentation and by chemical synthesis. Cereal grains, sugar, molasses, and other natural products, are the major raw materials for the fermentation. Beverage alcohol must by law come from these raw materials. Synthetic alcohol is produced from petroleum-based oils or gasses. Industrial fermentation alcohol and synthetic alcohol are chemically identical. The present anual United States industrial (nonbeverage) alcohol market is about 300 million gallons and the alcohol is almost entirely synthetic because it is lower in cost.

Practically all natural products high in starch or sugar could be used to produce industrial ethyl alcohol by fermentation. Corn and sugar byproducts (molasses) have been selected in the past because of low cost. Wheat, sorghum, and other materials, have had relatively minor use. However, during World War II (1942–1945), when alcohol need was critical for synthetic rubber production and cost was of lesser importance, about 250 million bushels of wheat were used for alcohol production. The alcohol yield from all these materials is theoretically in direct ratio to the contained starch or sugar per unit weight. In practice, the chemical and physical properties of each natural raw material affect the production to some degree. The most important byproduct of the grain fermentation operation is residual, distillers grains, containing all of the original ingredients, except the starch or sugar. This byproduct has a protein content of 20 to 30 percent depending on the type of grain and its original protein content. This high protein byproduct has been used as animal feed.

Synthetic alcohol has developed since 1929 and now supplies the industrial alcohol market. Most of this alcohol is produced from ethylene obtained from petroleum and natural gas. Newer synthetic alcohol plants are relatively large with minimum annual capacities in the order of 50 million gallons.

Ethyl alcohol has had use in some countries as a component of motor fuels. In the United States petroleum products have generally been the least expensive fuel and therefore furnish the best motor fuel. It is possible to use gasoline-alcohol blends in present engines with acceptable performance. A blend should contain at least 10 per cent (by volume) alcohol to prevent handling and separation problems and must be anhydrous alcohol. Lower proportions of alcohol might be used, but would necessitate dual or more expensive carburetor systems.

The basic problem hindering this utilization has been unfavorable economics. Legislative action that would require the use of alcohol blends with alcohol produced from cereal grain (i.e., wheat) would be required for a significant volume motor fuel alcohol market. Through such legislative action, all motor fuel could be required to contain at least 10 per cent ethyl alcohol, produced from United States cereal grain (types and ratio could be specified) in U.S. plants. The market for grain created by such legislation would be very large. The annual U.S. consumption of automobile fuels is about 85 billion gallons. Over 3 billion bushels of cereal grains would be required annually to produce the 8.5 billion gallons of anhydrous alcohol for a 10-percent blend.

Capital investment for the approximately 500 fermentation plants necessary to produce this amount of alcohol would be in the order of $6 billion. Practically all the fermentation plants would be new.

About 25 million tons of high protein byproduct distillers grains would also be obtained. The effects of this quantity of byproducts on the animal feed market have not been evaluated. The feeding value of these distillers grains varies, according to F. B. Morrison's book, "Feeds and Feeding". According to Morrison, insufficient data are available on distillers grains from wheat for comparison, although Morrison implies that the wheat product should be comparable to that from corn.

The effect of alcohol blends on motor fuel costs depends on many factors, including grain prices, conversion costs, byproduct feed values, profits, and other expenses. Assuming such a program were legislated, the alcohol blend would add about one cent per gallon plus the grain cost. Grain at $1.00 per bushel would add 4 cents per gallon, making a total increase cost of five cents per gallon. The effect of grain prices on the alcohol cost is shown in the attached table. In all cases, the costs do not include any allowance for profits, packaging, and sales expense.

Tetraethyl lead (TEL) is now used in more than 97 percent of all motor fuels. Its proposed removal for pollution control will require major revisions in petroleum refining procedures, automotive engine design, and fuel blending. The economics of producing the engines and lead-free fuels is now a major and unresolved subject. Increased fuel costs by refining, as reported in several journals, have been in the 2.5 to 4.0 cents per gallon range and the required capital expenditures have been estimated at $4.2 to $6.0 billion. The use of an alcohol-gasoline mixture in automobiles would be a lead-free fuel that would eliminate lead pollution from auto emissions.

Ethly alcohol could have an important role also in controlling hydrocarbon pollution from automobile emissions but apparently would not completely eliminate pollution from this source. The Southwest Research Institute reported (Air Pollution Control Association Meeting, Houston, Texas, June 1964) that 25 percent alcohol-gasoline blends resulted in average reductions in exhaust hydrocarbons of 25 to 30 percent; and a few individual tests showed greater reductions. More complete information on modern engines is needed for definite conclusions.

For maximum reduction of pollution from exhaust emission, catalytic converters to remove the products of incomplete combustion appear to be a favored approach. Tests with catalytic converters have indicated the lead in present gasoline that passes through the exhaust poisons the catalyst and destroys its ability to control hydrocarbon pollution. It is most probable that the combustion products of gasoline containing 10% alcohol would not poison the catalytic converter. These converters are being perfected by automobile manufacturers and scheduled to be installed on all cars in the future. Converters would presumably last much longer with the alcohol mixture than with the present lead additive. This prospect could be substantiated thorugh research in a relatively short period of time and should be initiated immediately if plans are made for the use of alcohol-gasoline blends in motor fuels.

EFFECT OF WHEAT COST ON ETHYL ALCOHOL COST

[Basis: 2.6 gallons 200-proof alcohol per bushel]

Wheat price per bushel	Alcohol cost per gallon (cents)		
	Wheat	Conversion	Total base cost
$1	38.5	21	59.5
$1.25	48.0	21	69.0
$1.50	57.7	21	78.7

Note: These costs do not include profits, packaging, and sales expenses.

Senator RANDOLPH. Senator Dole?

Senator DOLE. Mr. Chairman, I would like to commend the work of Dwight Miller in the Research of Better Utilization of Wheat. His work at the Northern Regional Research Laboratory of the Department of Agriculture in Peoria, Ill., resulted in his appearance before the National Wheat Utilization Research Conference in Oakland, Calif., last November. Mr. Miller's work—and his testimony has been directed to the utilization of alcohol made from grain in a mixture with gasoline as a fuel for automobiles. Such a mixture would replace the tetraethyl lead now added to gasoline to boost octane, but which pollutes the air through exhaust emission.

I would like to thank the Agricultural Research Service of the Department of Agriculture for cooperating with us today in providing the time to Mr. Miller to act as a witness for this committee.

Senator RANDOLPH. Thank you, Senator Dole.

Senator Baker?

Senator BAKER. Mr. Chairman, may I also say at this point I was most impressed by the statement made today by Congressman Kleppe with respect to the use of alcohol manufactured from grain as an additive to gasoline. I think the statement shows Congressman Kleppe's usual well-reasoned logic and that there will be a very great use for this information on the committee.

Senator RANDOLPH. Do you want that included?

Senator BAKER. No; I believe the text of it has been included previously, Mr. Chairman, when the Congressman was here to testify this morning.

Senator RANDOLPH. Thank you.

Senator BAKER. May I thank the Secretary and the Administrator for being here and giving their testimony today.

I have only one or two things I hope to ask and maybe you can add some information for the completion of this record.

A point made by Senator Hart this morning related to the installation of the devices to control smog and exhaust emissions of motor vehicles and the necessity for their routine periodic maintenance, and the functioning efficiency of those devices with relationship to maintenance.

That brings to my mind an overall question, Mr. Secretary, that I believe I have asked every witness who has testified on this subject. I don't have any desire to put you on the spot, but I would appreciate your present judgment in this respect.

Do you anticipate that the internal combustion engine essentially as we know it and as utilized in motor vehicle transportation, can be modified and a fuel adapted in order to provide exhaust emission that will meet the 1975 criteria and the 1980 goals?

Put another way, Mr. Secretary, do you think the internal combustion engine can survive in the future as an acceptable means of propulsion for the public of the United States?

Secretary VOLPE. Senator, I wish I could get completely specific in responding to that question. I will try to be as specific as I can.

I am not a gambler but if 6 months ago you had asked me that question I probably would have said I don't believe that would be the case, that they could meet neither the 1975 standards nor the 1980 goals. I would say today that based on both my observation in Detroit, a good deal of reading I have done, additional research that has become available to us, and the inspection of various devices that I have looked at outside of the automobile industry, I belive rather firmly that the internal combustion engine will be able to meet the standards for 1975.

Senator BAKER. Mr. Secretary, I agree with you entirely. Six months ago I said in this committee at the time the distinguished innovator, Mr. Bill Lear, testified that I doubted that the internal combustion engine as we knew it could continue to exist against the public pressure for cleaner air, and I am inclined to think now that it can continue to exist in view of the development of thermal reactor mufflers, new fuel systems, fuel ejection systems, and the like. This is indicative of how our view of this field shifts and changes in a relatively short period of time.

Does your Department intend to move forward as it has previously on a broad front of investigation of all types of propulsions for our public vehicles; that is, internal combustion, unconventional vehicles, and the like?

Secretary VOLPE. Subject to the assignment of responsibilities by the Environmental Quality Council. We are already doing work in this field as you know, and subject to their future assignment of responsibilities in this area, we will continue to carry it out.

Although I believe very strongly that what I said a moment ago is true, nevertheless even though I believe as a result of the way I try to live I will live to be 70, I still have an insurance policy. I think I would like an insurance policy here, too. For that reason, we should proceed with the unconventional engine and other possibilities so that if something should happen along the line and internal combustion engines cannot make it, we would be ready with something else rather than have to spend another 5 years finding that something else. So we certainly ought to continue our efforts in this area. Even if we find that these internal combustion engines can be cleaned up and will do the job, it is possible that the research will find a means that is cheaper.

Forgetting the pollutants, assuming that the internal combustion engine does eliminate the pollutants by the technology that is developed, it could be that you would develop a type of propulsion less costly to repair. So I don't think our research in this field would be wasted in any sense.

Senator BAKER. Do you have any difficulty working with HEW in tandem as a team effort in trying to approach this problem?

Secretary VOLPE. Secretary Finch and I have absolutely no problems at all.

Senator BAKER. Under the provisions of the Muskie bill and the administration bill, would you find that you would continue that relationship to one extent or another successfully?

Secretary VOLPE. Yes. In all of our endeavors on these devices we talked about, either Bob Finch called me and said, "John, we would like to move in this field, we would like to have your views and have some of your people available," or vice versa. We have worked together very nicely.

Senator BAKER. After all, that is the end product, the result of such cooperation, rather than a clean, simple organization.

Secretary VOLPE. That is right.

Senator BAKER. Mr. Chairman, thank you very much.

Senator RANDOLPH. Thank you, Senator Baker. Tomorrow morning, Senator Baker, we will be hearing from representatives of the automotive industry. I hope you will be privileged at that time to continue this form of discussion with those who will be here to testify.

Senator Hart?

Senator HART. No questions.

Senator RANDOLPH. We want to thank you, Mr. Secretary, and Mr. Administrator, and those of your associates who have come to counsel with us this morning. We are not discouraged. I was told the other day about a professor who was asking his students to major in a class called "Discouragement." I don't know whether that is common on our campuses today. I hope there will be some major courses on encouragement. In other words, I think we must take a very hard look at the mistakes we have made and we must also realize that this country has met challenges and that we can meet this challenge, and you help us in counseling as you have.

Secretary VOLPE. Thank you very much, Senator.

Senator RANDOLPH. We will take just a couple of minutes here before Mr. Baron comes forward.

(Brief intermission.)

Senator RANDOLPH (presiding). We are ready to resume the hearing and will now hear from Mr. Robert Alex Baron, who is representing Citizens for a Quieter City, an organization, I would infer, dedicated to noise abatement.

With that in mind, I believe it would be helpful to the record to include at this point a paper prepared by Mr. Edgerton, of the subcommittee staff.

(Document referred to follows:)

BRIEFING PAPER: NOISE POLLUTION

BACKGROUND

Complaints about noise are almost as old as organized society. Julius Caesar, responding to citizen complaints about noise, banned chariot traffic in Rome at night. Englishmen in the 16th Century were prohibited from beating their wives after 10 PM because of the noise. Disturbing though these historical noise levels may have been, modern urban man must endure a much more varied, higher level of noise, and it has become one of the major annoyances of city living.

Trucks roar along arterial highways late into the night, intruding on the sleep of many a nearby resident. In the morning, the urban dweller may be awakened well before he intended to get up by the clang of garbage cans or the steely chatter of a jackhammer. If he is unfortunate enough to live near an airport, the roar of jets interferes with his sleep and his family life. If there is a music-loving teenager in the family, the noise of rock 'n' roll bands may be threatening him with hearing loss.

Noise is coming more and more to be seen as a health problem. There is clear demonstration of hearing loss in continued exposure to high noise levels, as in factories. But perhaps more important for the general population, there is considerable indication that noise can affect blood pressure and heartbeat, and have detrimental physiological effects other than hearing loss. Recent research indicates that loud noises may adversely affect developing fetuses. Psychological and mental health effects of noise are more difficult to measure, but many researchers believe noise-induced mental tension can have adverse effects.

There is beginning to be some public recognition of noise as an environmental pollutant, but there is much to be done before any real progress is made.

MAJOR PROBLEM AREAS

I. Occupational noise

Studies show that factory workers exposed steadily to high noise levels have poorer hearing than other population groups. It is in this area that an undeniable health hazard exists. As many as 16 million workers are exposed to such conditions.

There is a new program of Federal regulations in this area, but full compliance will take considerable time.

II. Aircraft noise

Although affecting mainly those living near airports or under flight paths, aircraft noise produces the loudest complaint from those affected, and most recent public attention given to noise has centered on airplanes. The number of citizens affected may increase dramatically by the late 1970s, when the SST is expected to be in flight and sonic boom is produced.

The FAA has published its first set of regulations on noise, but has yet to effect any significant noise reduction.

III. Traffic noise

Although not so severe an irritant to those affected as aircraft noise, traffic noise affects a broader segment of the population. A survey of three major cities commissioned by HUD (excluding neighborhoods near airports) found that of those bothered by noise, traffic was the greatest source of annoyance. Of those bothered by noise, more than 15 percent said traffic noise bothered them most. Especially cited were trucks and motorcycles, the noise of which rises above the steady hum of auto traffic.

Some action in this area has begun at the state level. California has a statute setting maximum noise limits for highway traffic and has been stringently enforcing it. New York has had such a statute on the books since 1965, but has done little in enforcement. Because of the police power involved, state and local government seems the proper level for direct regulation in this area.

IV. Outdoor noise

The resident of a large metropolitan area, whether a central city dweller or suburbanite cannot escape noise in the streets in his neighborhood. Depending on its level, it may or may not penetrate into his home.

To those living in the city proper, it seems that something is always being built, torn down or dug up, with a full complement of jackhammers, compressors, pile drivers and other noise equipment. The racket may wake him in the morning, and, in some cases, even keep him awake at night.

In the suburbs, the noise sources are more likely to be shouting children, barking dogs, or the roar of lawnmowers or other power equipment. But this can be just as annoying and tension-producing, especially in view of the lower level of background noise. In the previously-cited HUD survey, respondents cited such community noise as the second-ranking irritant after traffic noise.

V. Indoor noise

Increasing economies in construction have led over the years, especially in apartment buildings, to a situation where a resident can hear his neighbor playing the radio, flushing the toilet and talking to his family.

The problem here is not only the thickness of the walls but also the noise-suppressing qualities of the plumbing and heating equipment and other fixtures.

Such things must generally be regulated by local building codes. New York City is the only major city to have taken significant steps in this direction.

CURRENT FEDERAL REGULATION

I. Occupational Noise

In May, 1969, the Secretary of Labor used, for the first time existing power to set standards for industrial noise for firms holding government contracts of $10,000 or more. The maximum level was set at 90 decibels where a worker has continuous eight-hour exposure. Nearly 60% of the Nation's work force is covered by these regulations. Hearing loss begins with steady exposure to between 80 and 90 decibels. As a point of comparison, an office with tabulating machines is about 80 decibels, a construction hammer 110, a rock'n' roll band 100 plus, a kitchen food blender 95. On this logarithemic scale, a drop of about 10 decibels cuts sound in half.

Many factories find it difficult to meet these standards. Current enforcement practice requires a firm to hold the noise level as low as technologically and economically feasible. If the noise level is still above the maximum, a hearing conservation program, such as earplugs or over-the-ear protectors, is required.

The Department of Labor says, however, that it intends to require stricter compliance as firms buy the next generation of machinery.

Legislation now pending would extend authority to set noise and other safety standards to all industry, not just firms with government contracts.

A law enacted in 1969 allows the Labor Department to set noise standards for construction equipment for any work done with any government financing. Such standards must reflect concern for health hazards to the workers. The Department is working on these standards, which are expected to be promulgated later this year.

II. Aircraft Noise

The Federal Aviation Administration was directed by 1968 legislation to issue standards for noise from jet airliners. Planes that do not meet standards can be refused certification. The first of these regulations promulgated in November 1969, sets a maximum level of 108 decibels for the heaviest aircraft during takeoff and landing (compared with current levels of between 110 and 120 decibels). These standards, however, will have their first application to planes coming into service in 1971 or 1972.

The FAA currently is considering whether (under the legislative guideline of doing what is "economically reasonable and technologically practicable") the standards should be applied to planes now in service. The airline companies in general are arguing that this would be too costly.

CURRENT FEDERAL RESEARCH

Total research expenditures related to noise were about $25 million in fiscal 1970. Of this, NASA, doing research on quieter airplane engines, was budgeted for $16.8 million. Department of Transportation, which worked closely with NASA on airplane engines and on its own projects, had a budget for noise of $5.3 million. Other departments: HEW $1.1 million; HUD $490,000, Commerce $410,000. No exact breakdown were available for Defense or Labor.

General area of research by department:

NASA.— Quieter airplane engine.

DOT.—Aircraft noise abatement and surface transportation noise.

HEW.—Health effects of noise in general, emphasis on hearing loss.

HUD.—Noise transmission of structural materials; land use around airports with view to reduction of noise effects.

Commerce.—Specifications for acoustical instruments and for acoustical materials. Commerce also has study panel doing general report on noise.

Labor.—Standard-setting in relation to Walsh-Healey and related acts.

Defense.—Noise effects on humans relating to combat effectiveness. Much of research relates to special military conditions and thus does not have wide applicability.

POSSIBLE OBJECTIONS TO TITLE II, S. 3229

Some departments maintain that the noise effort, rather than being focused in a noise abatement office in HEW, should be coordinated through an inter-agency committee, with each department continuing its current efforts. While it is desirable that research in various departments be continued, there is a strong case to be made for putting the focus of noise abatement and control in the department where it is most certain to be treated as a health problem. As with other forms of pollution, noise produced or aggravated by a certain activity may be seen as an incidental concern by the agency whose mission it is to develop that industry or activity (e.g. transportation, housing).

FUTURE AREAS OF LEGISLATIVE CONCERN

Some area that an HEW office of noise abatement should be urged to consider in submitting legislation recommendations to Congress:

(1) The possibility of requiring noise standards for direct Federal activities and programs which require Federal grants, contracts or authorization;

(2) The possibility of requiring structural noise standards in the construction of urban renewal or other Federally-financed construction. Noise standards for construction equipment in this area might also be considered (Labor Department standards will relate only to the construction worker, not the surrounding populace).

(3) Federal agencies such as GSA, Department of Defense, might be required to have best-possible noise abating equipment on all vehicles and equipment bought.

(4) There might be consideration of sponsoring a broad anti-noise educational campaign, similar to that mounted against littering. Municipalities such as Memphis, where there is a reasonably successful noise abatement ordinance, have found much of the desirable results dependent on convincing the public that lowering the noise level is an aim worthy of personal consideration.

Senator RANDOLPH. This hearing will now resume. Mr. Baron, if you will identify yourself for the record and the organization for whom you speak, sir.

STATEMENT OF ROBERT ALEX BARON, EXECUTIVE VICE PRESIDENT, CITIZENS FOR A QUIETER CITY, INC., NEW YORK, N.Y.

Mr. BARON. My name is Robert Alex Baron and I am executive vice president of Citizens for a Quieter City, Inc., New York, N.Y.

Senator RANDOLPH. You may proceed as you desire, sir. We are very gratified to have you with us and we appreciate your counseling.

Mr. BARON. Thank, you, Mr. Chairman.

Mr. Chairman and members of the committee, I should really call my statement "Noise Today" because I am hopeful that this statement will not be valid for too long.

Noise has "growed" like Topsy. This byproduct of modern day technology and congestion has made the public an unwilling quinea pig for dawn-to-dawn noises at levels and frequencies that did not even exist 30 to 40 years ago.

The growing concern of the public is indicated by the formation of noise abatement organizations such as Citizens for a Quieter City, the Citizens League Against the Sonic Boom, a new national organization of local governments to come to grips with jet noise, and the inclusion of noise pollution in the environmental teach-in and action programs that are taking place now and in April. Noise pollution will be on the agenda of the 1972 U.N. Conference on the Human Environment. The urban noise problem led to the report of the mayor's task force on noise control, New York City, 1970.

Though our tolerance of noise is decreasing, recognition of the problem in research and government circles is at best scattered. Our universities lack adequate noise control programs and adequate acoustic laboratory facilities. The Federal Council for Science and Technology describes noise control research in the universities as insignificant in view of the magnitude of the problem.

Society does virtually nothing to control noise, even those most intense and intrusive. Noise abatement is virgin territory, and human beings are forced to live in a state of acoustic anarchy.

By far and large all levels of government have neglected the noise issue. Noise is an orphan among the pollutants. For example, though action programs are being developed to reduce the noxious emissions of motor vehicles, we omit goals for reducing the noise emissions of such vehicles. Only two States, New York and California, have decibel limits for motor vehicles; in both cases the limits favor the motor vehicle, not the residents living near highways. Municipal regulation of motor vehicle noise is either nonexistent or ineffective. We hear that the automobile industry is working now to develop even louder horns because they say city noises have increased so much that the existing horns are not adequate.

The typical municipal noise ordinance exempts the intense noise sources; construction equipment, central air conditioning, ventilating systems, etc. In the rare cases where there is a ban, enforcement is a rarity—such as the use of auto horn except in case of danger. Disruptive noises from aircraft cannot be regulated by local governments as such regulation has been preempted by the Federal Government. Municipal governments do not have access to the funds and the expertise needed for noise control programs.

Most municipal governments and most State governments apparently neglect instituting noise abatement functions.

The failure of the Federal Government to respond to the noise problem is documented in the report "Noise: Sound Without Value," published by the Committee on Environmental Quality of the Federal Council for Science and Technology, June 1968.

The question now arises: What agency or agencies of the Federal Government shall be involved with noise abatement? Not being an expert in public administration, I cannot suggest the answer at this time. However, it is my considered judgment that the Department of Health, Education, and Welfare must be given a major role in any Federal noise abatement program.

The noxious effects of noise are many: Economic, social, medical, and psychological. Is noise a health problem?

Noise is the most personal and the most immediately painful of the so-called pollutants. It does not hit the human being in his lungs or stomach, but in his mind.

Dr. Samuel Rosen, noted ear specialist and medical researcher, has described the generalized impact of noise intrusion:

> It would seem that loud noise can increase body tensions, which can then affect the blood pressure, the functions of the heart, and nervous system. The psychic effect of noise is very important. Noise can cause enough emotional response and frustration to make a person feel nervous, irritable, and anxious. Rest, relaxation, and peaceful sleep are interrupted and often denied to those suffering from illness. We now have millions with heart disease, high blood pressure, and emotional illnesses who need protection from the additional stresses of noise. (Medical Tribune, Jan. 4, 1968.)

Dr. Gerd Jansen, with the Ruhr University, West Germany, one of the few researchers performing original research on the extra-auditory effects of noise on man, told the Conference on Noise as a Public Health Hazard (June 1968):

> As several investigations have demonstrated, sounds or noises do change the physiological state * * *. Until someone proves that these physiological changes are negligible, we must consider noise to have a possible detrimental influence on human health.

Our understanding of the impact of noise on man is incomplete, in part because of the complex nature of human response to noise, and in part because of the meager research.

At that same Conference on Noise as a Public Health Hazard, former Surg. Gen. William H. Stewart stated that we need to know more about how noise damages hearing, the effects of noise on job performance and work efficiency. We need to investigate noise effects in the community where people live.

The latest input on noise and health was reported at the American Academy for the Advancement of Science symposium on the physiologic effects of audible sound. The Medical Tribune report of the

American Academy for the Advancement of Science (January 26, 1970) stated that: "the full potential of noise's harm to human beings is still undreamed of, because such investigations are only beginning. Summing up at the end of the symposium, Dr. Chauncey Leake, University of California Medical Center, San Francisco, said: "What it all means is that much more study must be done—and quickly."

On the basis of the above evidence, it would seem that there is a strong case for abating noise as a precautionary measure, if nothing else.

Yet, as noise exposure has increased health departments in the United States have not kept pace. Municipal health departments are content to have noise regarded in its traditional context as a nuisance to be handled by the police.

State health departments have failed to develop noise abatement programs. One reason is the tendency to define the effects of 20th century noise in terms of 19th century medicine and concepts of public health. For example, in 1963, New Jerseyites complained about industrial and transportation noises, calling them health hazards because they interfered with sleep and eating and because life in general was made miserable. In 1963, the New Jersey State Health Department took the position that evaluated against today's standards these noises are not a health hazard. They do not directly produce disease. I would like to note that New Jersey is seeking to expand its noise abatement program.

Perhaps it is best to consider noise in context of the new definition of health originated by the World Health Organization: "Health is a state of complete physical, mental, and social well being, and not merely an absence of disease and infirmity."

The Public Health Service noise laboratory in Cincinnati conducts in-house research dealing with noise effects on overall health, productivity, and well being, plus aspects of environmental noise control. In 1968 the staff for this monumental project consisted of eight people, with an operating budget of $150,000. Since then, I understand, even this minimal effort has been reduced.

Granted the need for adequate studies, I am disturbed by the neglect of any effective programs for noise abatement.

We know how to produce quieter vehicles, subways, air conditioners, lawn mowers, and so forth. There are guidelines for designing quiet homes and quiet appliances. When it comes to converting guidelines into action programs we are told we must wait for perfection. Why must we wait? Almost every community has an ordinance prohibiting disturbance by barking dogs. The ordinances do not specify the size of the dog or the noise level of the barking. It is accepted that barking disturbs sleep, and sleep must be protected. Yet when it comes to aircraft, trucks, air conditioners and appliances, we must accept noise levels that disturb sleep.

European manufacturers have been leaders in the design and manufacture of various quieter items. In 1966 I first saw a quieter garbage truck in Baden Baden, Germany. There I also observed quieter air compressors, jackhammers, and motorcycles. Citizens for a Quieter City arranged demonstrations of some of these items in New York City, and now Ingersoll Rand and other manufacturers are producing a limited line of quieter pneumatic tools for the U.S. market.

Incentives for quiet design must be forthcoming if we are to protect our environment.

At what point do we decide to abate as well as to study?

In the early 1900's when the automobile muffler was developed there was no conclusive knowledge of the effects of noise, no sophisticated decibel measurements. Society decided that unmuffled motor vehicles disturbed horses pulling wagons and insisted that vehicles be designed that would not frighten horses. Unfortunately, human being have exercised more self-control than horses, and muffler improvements seem to have started and stopped at the horseless carriage age.

There is no excuse for being forced to live in homes that offer no escape from noise intrusion. Yet only one city, New York, has a building code with noise control provisions. Not completely adequate, but a beginning. In general, we permit our architects to design homes as if they were to be built in silent deserts and for use by creatures without any ears or nervous systems. Five years ago the President's Science Advisory Committee recommended: "that the Federal Government encourage the development and adoption of codes governing noise insulation in apartment buildings." This recommendation lies dormant.

Some believe noise abatement must wait until air pollution and other seemingly more pressing environmental problems are solved. Today's environmental insults cannot be treated sequentially. Technology moves too fast. The human race no longer has the luxury of taking care of each pollutant in sequence. Time is running out. We must attack pollution on all fronts, noise included.

To attain a quieter society, we will require a partnership of the public, industry, and government. The public must be taught to abate those noises it can control. It must also be taught to prod industry to design for quiet. However, only government can exercise the necessary overall control, leadership, and authority to develop and enforce the necessary standards and ground rules.

We must not wait for proof that noise can kill. We must start now to think noise and to design for quiet. We must end the tyranny of noise.

Thank you, Mr. Chairman;

I have, incidentally, several documents that I would like to include in the record and I will submit them.

Senator HART (presiding). They will be received.

(The document referred to follows:)

[Reprinted from American Journal of Public Health, November 1968]

NOISE AND URBAN MAN

(By Robert Alex Baron)

Increasingly, noise in the environment is a problem. A view of the problem as seen by an executive of a citizens' association which is working for more effective noise control in New York is presented. This is another aspect of the environmental problem discussed in the preceding symposium, and indicates the point of view of the public.

Noise abatement and the need for it are virtually neglected issues in American life today. Unless the medical and public health professions become deeply involved in these problems, it is likely that apathy and inertia will defer any effective action for another decade or even longer.

But we—the public—cannot wait that long. Air pollution kills us slowly but silently; noise makes each day a torment. "Noise is a molester" to Dr. Samuel Rosen, ear surgeon and investigator in epidemiology of hearing loss.[1] It has been recognized by a World Health Organization committee as a detriment to well-being.[2]

Urban man lives in increasingly congested cities that are noisily bursting from their seams. Demographers predict that by the year 2000, 50 per cent of our population will live in three supercities, which someone has named "Boswash," a megalopolis stretching from Boston to Washington; "Chipitt," stretching from Chicago to Pittsburgh; and "Sansan," encompassing the area from San Diego to San Francisco.

New York City, which is often criticized for its noisiness, demonstrates what will happen in tomorrow's cities if the science and technology of noise control are not somehow applied to urban environment, as well as to the environment of outer space and space launchings, military efforts and industry. And New York's extreme noisiness differs from that of many other cities only in degree; nor are urban man and his fellow inhabitants of cities the only sufferers. Thanks to the "blessings" of aviation, the new network of nationwide throughways and agricultural machinery, many surburban and rural areas are no longer havens of quiet.

DAILY DECIBEL DIET

Demolition and construction for urban renewal and city expansion can often make urban man a victim of an excessive decibel diet that starts at seven o'clock in the morning. Jackhammer reveille . . . garbage truck reveille. This is the legal time for starting "socially useful" noise-making. In the United States, this type of noise and its levels are exampt from control. Human beings can be exposed to even harmful levels of noise if the noise is created for something society "needs," such as construction or center-city helicopter flights for sightseers.

Ripped from his bed by a socially approved jackhammer, our urban early riser finds himself at breakfast listening to high-level food-blender racket, and intense noises from exhaust fans over range hoods, dishwashers, garbage disposal units, and vacuum cleaners. Enroute to work, the urban man endures 90 or more decibels of noise, no matter whether he travels by subway, by bus, or by automobile with the window open.

At work he may be assaulted by high-level, ear-damaging noise from automated clerical and computing equipment of the type used in the check-tabulating room of a large New York bank. According to the National Association of Hearing and Speech Agencies, this bank, which had experienced a high degree of employee turnover because of noisy work conditions, finally resorted to hiring the deaf.[3]

Our city man in his office is sometimes unable to make himself heard because of interference from helicopters and jets, from traffic and work at construction sites. Lunch hour, in most restaurants, is a nerve-wracking cacophony of dish clatter and loud voices.

After work, he is subjected to another dose of transit noise. At home, he is bombarded by noise from within his building and from without. He probably is forced to listen to his family's TV set, his neighbors' TV sets, and details of his neighbors' personal lives, as well as to the air conditioners in his own quarters. Any time during the night his sleep may be disturbed by many noise sources: buses, trucks, motorcycles; the sirens of fire engines, police cars, and ambulances; auto horns, barking dogs, planes—and his neighbors' air conditioners.

There is no escape during leisure time in the city or in the country. Street noises prevent sleeping late on Saturdays or Sundays. The jets may follow the urban dweller to the beaches, and power lawnmowers may follow him to his country retreat. "Ear pollution," said ecologist William Vogt, "has been mentioned in relation to airplanes. It should also be recognized as one of the striking characteristics of state park campsites."[4] Where can one go for quiet, undisturbed relaxation? Not even to a hospital! Even there patients are exposed to noise which interferes with their rest and sleep, so necessary for healing and convalescence.

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[1] Rosen, Samuel. Health Hazards of Noise. Paper presented at New York's First Conference on Urban Noise Control, sponsored by Citizens for a Quiter City and the Borough President of Manhattan. New York City, N.Y. (Mar. 18). 1967.

[2] Environmental Health Aspects of Metropolitan Planning and Development. Geneva: World Health Organization. Tech. Rep. Ser. No. 297, 1965, pp. 51–52.

[3] "New York Employs Deaf." In: Hearing and Speech News (Jan.), 1967, p. 7.

[4] Vogt, William. Population Patterns and Movements in Future Environments of North America. Edited by F. F. Darling and John Milton. New York, N.Y.: Doubleday, 1966, pp. 372–389.

Noise has "growed" like Topsy. This urban by-product has reached unprecedented dimensions. Today's dawn-to-dawn noises are not yesterday's, either in energy content, spectrum distribution, duration, stimulus frequency, or any other noise characteristic.

It took 40 years to demonstrate overwhelmingly what many doctors knew intuitively when cigarette smoking was introduced. Air pollution is another case where we waited too long for proof of cause and effect before deciding to take action. The public today is an unwilling guinea pig being exposed to types of noises and noise levels that did not exist 30 to 40 years ago.

Where is there concern from the American public health community about this excessive noise exposure, or the threat of the sonic boom, which promises thunderous farewell to any hope for undisturbed sleep? Of course, anyone can "solve" his sleep problem with 1½ grains of Nembutal every night.

To the credit of European public health authorities, they are very much involved with noise abatement. The German Federal Minister of Health was the welcoming speaker and a co-sponsor of the Fourth International Congress for Noise Abatement at Baden Baden. In the Netherlands, noise standards for dwellings are developed by the Research Institute for Public Health Engineering. Local health authorities in England take an active role in reducing construction noise and solving other community noise problems.

It is a strange reversal of events that, as noise exposure and its harmful possibilities have increased, health department interest in the United States has not kept pace. For example, all noise sections that had once appeared in the New York City Sanitary Code have been transferred to the Administrative Code for police enforcement. I discovered this personally when the New York City Health Department could not curb the solid year of 103 decibel noise generated outside my apartment by a battery of five air compressors and dozens of jackhammers and rock drills operating for ten hours a day, five days a week. The police could not act either, because this noise was and is legal!

NEED FOR CONTROLS

Two years later, a conference took place on urban noise control co-sponsored by Citizens for a Quieter City and the Borough President of Manhattan. A resolution was passed calling upon all levels of government to act against the excessive noise that is part of urban man's environment, but there was no noise control agency on any level of government to which this resolution could be addressed.

In 1963, New Jerseyites complained about the noises of industrial plants, commercial air conditioners, truck terminals, railroad freight yards and airports, calling these noises health hazards because they interfered with sleep and eating, and noting that "life in general was made miserable." The State Health Department[5] took the position that "evaluated against today's standards (1963), these noises are not health hazards. They do not directly produce disease." Perhaps not directly, but how about indirectly? Should not health departments adopt the definition of health formulated by the World Health Organization: "Health is a state of complete physical, mental and social well-being, and not merely an absence of disease and infirmity."

There are but three illustrations of neglect. This neglect is one result of defining the effect of twentieth-century noise in terms of nineteenth-century medicine and a nineteenth-century conception of public health. It is no longer sufficient that public health departments protect the citizen from impure milk, contaminated water, and communicable disease. They must also help to protect him from the seemingly limitless noises to which he is exposed.

Does it make sense for noise abatement control to be the concern of professionals outside the medical and public health communities? It certainly does not seem to, but the fact is that the few available noise abatement guidelines and functions are placed in the hands of nonmedical, nonpublic health agencies. On a national level, the Federal Housing Administration develops impact noise standards for dwellings are promulgated by the Buildings Department. Jet and supersonic aircraft noise criteria, if ever set at all, will apparently be set by the Federal Aviation Authority. It is time for organized public health influence to be exerted on the acoustic environment of this nation.

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[5] Schall, E. Lynn. Handling Neighborhood Noise Complaints. In: "Public Health News." N.J. State Department of Health (Nov.), 1963.

Congress, for example, must be made acutely aware of our noise problem. Until recently, the Public Health Service was not even authorized to list occupational hearing conservation as a separate budget item. The bill of New York City's Congressman Theodore Kupferman, advocating an Office of Noise Control to be set up under the Surgeon General's umbrella, appears to have died in committee.

Certainly, justification for action exists. Is it, then, illogical to ask that the American doctor and public health official take cognizance of this around-the-clock acoustic harassment that interferes with speech communication, that harasses the nervous system, that prevents restorative sleep? At long last, there are glimmers of recognition.

Here is what a World Health Organization Expert Committee reports about noise: "The effects of noise, even at a low level, are particularly detrimental in large urban areas where motor traffic and industry are highly developed, as large numbers of people in all age brackets (adults as well as children, sick as well as healthy) are exposed to them continuously. This health hazard increases every year as cities enlarge and the intensity of noise and vibration increases." [6]

Dr. Rosen told Citizens for a Quieter City's Conference on Urban Noise Control: Strong noises, loud noises cause other effects that cannot be willfully controlled by the recipient. Noise of any kind cannot be shut out from the ear as light can be shut out from the eyes. This means that the reflex effect which causes constriction of blood vessels occurs with equal intensity during sleep as during wakefulness. Not only do noise signals make the blood vessels constrict, but such noise causes the skin to become pale, muscles tense and adrenalin suddenly to be injected into the blood stream which increases tension and nervousness." [7]

The following statement is from the Public Health Service: "The effect of technological change on personal health and the health of whole communities is poorly understood, and is cause for serious concern. Even fragmentary knowledge leaves no room for doubt that human health and safety are threatened by the influx of . . . new sources and applications of energy, new sources of noise. . . ." [8]

For further justification, read the recent report of the Task Force on Environmental Health and Related Problems of the Department of Health, Education and Welfare: "The citizenry needs protection from noise as well as other environmental health threats . . Noise is an inter-related component of environmental health." [9]

DELAYED ACTION

This report is heartening to the public because it recognizes what we have known all along. What is disheartening, though, is its timetable for action. The procedure of government budgeting and financing of activities is such that the period between authorization and realization of an idea can take several years. In the interim, the noise assault will not halt; it will grow more ominous. To quote Dr. Vern O. Knudsen, physicist and a founder of the Acoustical Society of America: "Noise, like smog, is a slow agent of death. If it continues to increase for the next thirty years as it has for the past thirty, it could become lethal." [10]

If we delay action, if we do not act now, the noisy horsepower will roar out of the stable before we close the door. Every day sees an increas in the old noise sources, and every day brings closer the addition of new ones—the helicopters, the STOL's (short take-off and landing plane), the SST's (supersonic transport), jet-engined surface transportation, hovercraft, and so on. There is no excuse for waiting.

Machine noise control is no mystery. The Europeans have been applying such controls for at least two decades. There is much in our own military, space, and industrial noise control technology that can be adapted and applied to the general environment.

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[6] World Health Organization. Op. cit., p. 52.

[7] Rosen, Samuel. Op. cit.

[8] Health Protection: The Target of the Bureau of Prevention and Environmental Control. Washington, D.C.: PHS Publ. No. 1634, 1967, p. 27.

[9] A Strategy for a Livable Environment: A Report to the Secretary of Health, Education, and Welfare by the Task Force on Environmental Health and Related Problems. Washington, D.C.: U.S. Department of Health, Education, and Welfare, 1967.

[10] Short, Michael. "Noise—A Slow Agent of Death." In: New York World Journal Tribune (Apr. 23), 1967. Science Section, p. 12.

The city planners are waiting for advice, not tomorrow but now. The WHO Expert Committee, already cited, stated "one of the most important tasks of architects, acoustics engineers and public health personnel is to ensure that both in the general urban environment and in dwellings, noise and vibration are kept to a minimum . . . if planners are to develop effective programmes, they must rely on the environmental health professions for guidelines, standards, and justification in terms of health." [11]

Just as the city planner is looking for guidance, the stress-ridden American citizen is seeking protection from the intense and disturbing noises of his every-day environment. To whom shall he turn? The Chief of Police? The Commissioner of Health? Or a new Commissioner of Noise Abatement?

Noise abatement is a two-way street. The public health profession must recognize the need for urban noise control, and the public must support the "people-oriented" agencies. Industry has the FAA and the USPHS, space has NASA, and the military has its own alphabetese. What of the public?

Granted that occupational health is the primary concern of this audience—and no one can gainsay its importance—the everyday nonoccupational environment cannot be neglected, either. A little more than 14 million Americans are employed as production workers in manufacturing.[12] I estimate that the urban population today is at last 130 million. Whatever the source, noise is a noise is a noise, whether from punch presses, jets, jackhammers, subways or discotheques. Although man can leave his occupational environment, he cannot escape ear pollution. It therefore behooves us to become concerned about urban man's acoustic environment and help prevent damage not only to his hearing, but to his nervous system, his cardiovascular system—his total self.

Those of us familiar with the use of criteria for evaluating noise in industry should develop and introduce it to the general public. However, if this is done, the goals should be more humane than those in industrial hearing conservation, so that one can listen to music when retiring. Perhaps annoyance criteria for the general environment should be considered. The International Standards Organization is trying to win approval for a community annoyance standard. Help get this standard adopted and into practice. It may not be protective enough, but it will be better than our present state of acoustic anarchy. Pending protective standards and legislation serve as a moral link between the noise victim and the noisemaker. Pay immediate attention to the noise-sensitive areas, such as hospitals, schools, churches, and theatres.

To achieve a quieter city will require a new type of public health specialist —a humanist who will have to understand acoustics and acousticians, sociology, psychology, architecture, and politics. He will have to cooperate with city planners. Here is a stimulating challenge for the schools of public health. Federal funds for research, training and education are available from earlier Public Health Service programs. They go begging.

Noise abatement is a problem of astronomical size, involving us all. There must be a confrontation, and the medical and public health professions must be in the forefront. It is also high time that the otologists, who have borne the brunt of the work in occupational noise, be augmented by neurologists, endocrinologists, psychiatrists—the entire spectrum of the medical profession. We must learn more about the nonauditory effects of noise. A systems approach is needed.

Hopefully, some day Citizens for a Quieter City intends to play host to one of the international congresses for noise abatement. If our speakers were knowledgeable members of the public health field, as well as acousticians, architects and law enforcement officials, their presence would be a major achievement for the public health profession, and for our country as it enters the Urban Age.

CONCLUSION

An interesting medical case was reported in the Journal of Laryngology and Otology by A. J. Philipszoon, Chief of the Ear, Nose and Throat Clinic of the University of Amsterdam.[13] Professor Philipszoon refers to Rosen's hearing research among the Nilitic tribes in Africa, and his hypothesis that the noise of everyday life is an important etiological factor, among others, responsible for presbycusis. Rosen found that the older people in this tribe suffer much less from presbycusis than people of the same age in the United States. The Africans live in an atmosphere of virtual silence. With this in mind, Philipszoon reports the following Amsterdam case history:

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[11] World Health Organization. Op. cit., p. 51.

[12] U.S. Bureau of Labor Statistics Information Service. Personal Communication. (Oct.), 1967.

[13] Philipszoon, A. J. On the Cause of Presbycusis: A Case of Unequal Presbycusis of Both Ears. J. Laryng. & Otol. Vol. LXXVI, 8:593–595, 1962.

"A man, eighty-two years old . . . had the complaints of bad hearing usual in all patients with presbycusis. During the last years he became progressively deaf, and for that reason he consulted our department whether it was possible to get a hearing aid.

"At the examination we found a normal eardrum of the right ear. In the auditory meatus of the left ear we found much cerumen. . . . The "cerumen" proved to be a dirty piece of cotton wool from which fibers could be pulled and which had obstructed the auditory canal completely. When we asked the patient how this plug of cotton had come into his ear, the patient became very angry and told us that when he had an otitis, thirty-two years ago, the family doctor had left a plug of cotton wool in his ear! Although the patient had told the doctor that in his opinion there was still a plug of cotton wool left in his ear, the latter had told him this was not true. Thus nothing happened for thirty-two years!"

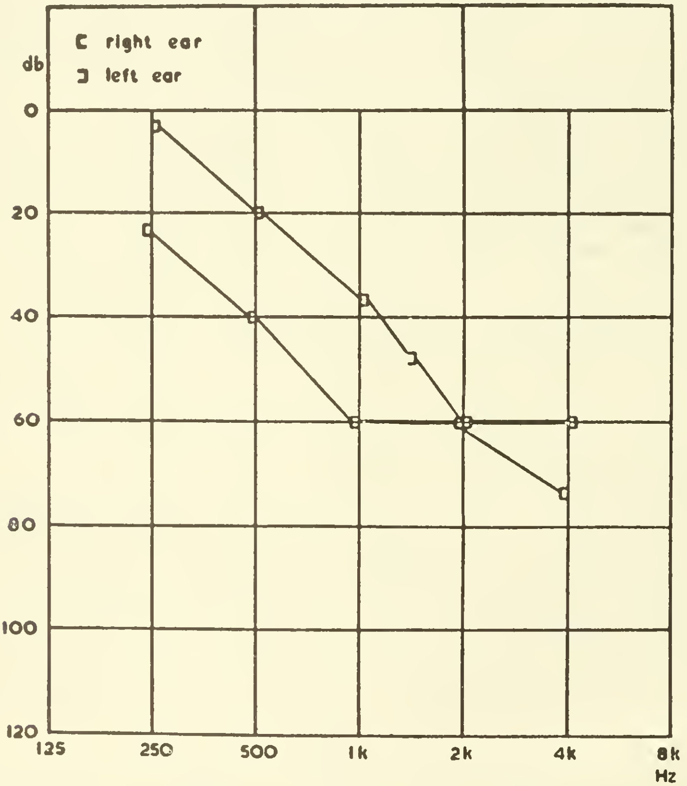

Figure 1—Audiogram of the bone conduction (Source: See reference 13).

After the cotton plug was removed, Philipszoon made an audiogram and was struck by his findings (Figure 1). In the right ear he found a normal presbycusis, a pure perceptive deafness, while the hearing in the left ear was much better and showed a mixed type of deafness. The most striking fact was that the bone conduction of the left ear was much better than that of the right ear. In his opinion the plug of cotton wool had functioned as an ear-defender for 32 years.

Philipszoon concluded his report: "In our opinion this case shows us 'experimentally' that for the onset of presbycusis the noise of every day is a very important factor as suggested by Rosen."

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This paper was presented before a Joint Session of the Industrial Medical Association and the Occupational Health and Engineering and Sanitation Sections of the American Public Health Association at the Ninety-Fifth Annual Meeting in Miami Beach, Fla., October 23, 1967.

ADDENDA

Since this paper was given, the American Speech and Hearing Association sponsored a Conference on Noise as a Public Health Hazard, supported by funds from DHEW. In his keynote address, Surgeon General Stewart agreed there was enough reason to move ahead on noise abatement without waiting for conclusive proof of every form of harm.

NOISE: THE AUDIBLE POLLUTANT[1]

CITIES COULD DO MUCH TO LESSEN NOISE LEVELS, CITIZEN LEADER SAYS

(By Robert Alex Baron)

One thing most member cities of the National League of Cities have in common: They seem to view city man as a creature without any ears. There is no city in the United States that protects its citizens from the excessive noises of the 20th Century, at a time in history when environmental sound levels are doubling every 10 years and when periods of quiet are disappearing.

Yet it is the cities that have the responsibility for noise abatement. Failing to exercise that responsibility they have given commerce and industry acoustic carte blanche. The result is that city life has become something to be endured, not something to be enjoyed. It is as if our mayors, city councilmen, and commissioners believed that an unlimited amount of sound and vibration were essential for man's comfort, health, and happiness.

City man is forced to endure noise exposures that irritate him, give him a headache, interfere with his sleep, and may damage his hearing. The Surgeon General of the U.S. Public Health Service has stated that sufficient evidence is available to warrant the curtailment of noise as a health hazard.

The noise explosion is most crucial in the cities, and I define cities to include the suburbs as well as the core cities. Today's urban noises must be understood in the context that our total population, now over 200 million, will exceed 300 million by the year 2000, when it is expected that four out of every five Americans will be living in cities.

Let's take a look at city man's daily decibel diet:

At 7 a.m. urban man first becomes aware that municipal government is not interested in noise abatement. This is the legal starting time for most of the noises of "social utility." He is awakened at that hour by the reveille played by noisy traffic, garbage trucks, jets, and jackhammers.

Construction noise vividly illustrates what is tolerated as a legalized "nuisance." Construction equipment is, if anything, more of an irritant today than it was 50 or more years ago. Construction noise was high on the list of complaints in 1930; it made the top 10 in 1956. Today the housewife, the young, the aged, and the ill, all must suffer exposure to unmuffled jackhammers, compressors, cranes, bulldozers, ad nauseum, victims of the mistaken notion that noise is a "natural" price of progress. Primitive is a kind description for procedures that exact a toll in degradation of the environment and hearing loss.

How do we abate construction noise? We do not.

Unlike several European cities which prohibit excessive construction noise, American cities exempt daytime construction from anti-noise ordinances, and allow as many loopholes for nighttime construction as there are utility projects and contractors in a hurry.

When urban man travels to work, whether in his private car or in mass transportation, he is traveling in a vehicle that exposes him to noise levels as high as 90 decibels and more.

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[1] Reprinted from Nation's Cities, September 1969.

How do we abate transportation noise? We do not.

There are more than 70 million automobiles in the United States, some 14 million trucks, more than 300,000 buses, not to mention subways. We do not legislate for quieter vehicles or plan to protect residential areas and hospitals from busy streets. Only a handful of American cities as much as mention decibel limits in local ordinances, and only two states, New York and California, have amended their motor vehicle laws to include decibel limits. None of these decibel limits bear any relationship to desirable noise levels for residential life. There are no national guidelines, and the automobile industry's voluntary standard for truck mufflers, adopted in 1954, is too permissive and not universally observed.

As for that bellowing adjunct to motor vehicles, the auto horn, it is as much a nuisance in 1969 as it was four decades ago. There are no standards for horns; and, with the exception, apparently, of Memphis, Tenn., antihorn laws are unenforced.

At the end of the commuting trail is a noisy factory or an equally noisy office. One bank has such a loud check-sorting operation it had to start hiring the deaf to reduce employee turnover.

We have no idea of the money lost in time wasted when noise interferes with office communications. We have little idea of the number of errors and accidents in which noise plays a part. We are just beginning to think of the fatigue caused by ingesting the unregulated acoustic insults.

After his noise-stressed work day, urban man retraces his noisy journey to return to a home which forces him to listen to excessively noisy appliances, and not only his family's TV sets, but those of his neighbors. American cities have not required noise insulation in dwellings, although European cities had such requirements starting in 1938. As a consequence of the lack of municipal requirements for dwelling noise insulation, both the post-war luxury apartment and the ghetto tenement are acoustic slums.

Urban man has even lost the right to sleep undisturbed. The entire sleeping city, including visiting businessmen in their hotels and motels, is harassed by auto horns, emergency vehicle sirens, garbage trucks, regular traffic, hot rodders, and noisy motorcyclists—and aviation. Garbage trucks are another illustration of the city's do-nothing program. In one 26-year period, garbage collection moved up to first place on the list of the 10 most disturbing city noises. Noisy garbage cans, permitted in all American cities (but not in Paris), add to the unnecessary early morning and nighttime noise of refuse collection.

Air conditioning is a growing evening and nighttime irritant. Not only do most cities fail to regulate air conditioning noise, some are relying on the "model" code being promoted by the Air Conditioning and Refrigeration Institute, a code designed to forestall effective municipal regulation.

Time for leisure does not mean periods of quiet. Surface and air transportation prevent rest and sleep on week-end mornings. Power lawnmowers disturb the quieter residential sections of the core cities and the suburbs.

This unprecedented decibel diet is blandly accepted as the price of progress, and noise pollution remains a neglected issue in urban life. Without any legal curbs, industry is content not to design for quiet.

Yet the technology is there. American engineers can, if they are motivated to do so, create an environment that would respect the human being. These specialists have provided the Army with an inaudible motor for front line use, the Navy with a silent submarine, and NASA with protection from the noise of rocket launchings. We know more about the acoustic environment under the seas than we do about that of our cities.

This acoustic expertise will flow towards the cities when municipal government recognizes that the quality of the environment is as important as economic growth, and, in fact, probably influences economic growth. Excessive noise depreciates residential property values; it is one reason the middle class flees the core cities. It forces the city to zone larger and larger sections to be free of residential use. Zoning now has to contend with not only the noise from a fixed installation, such as a factory, but the noise from power sources that move great distances on highways and in aerial corridors. Excessive noise is believed to be one reason for outbursts of violence in the ghetto areas.

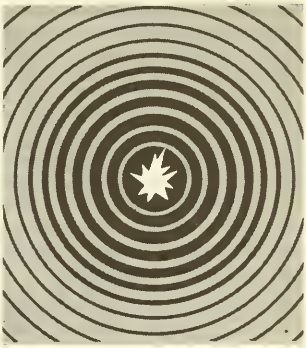
The burden of creating demand for noise abatement has fallen on the public. Citizens for a Quieter City is one example of how the public is responding to that responsibility.

Incorporated in 1966, its objective is to prove that peace and tranquility can co-exist with a highly industrialized society. It is trying to bridge the gap between what we know about noise control and what we apply to the everyday environment. Members of its boards represent a cross section of community life, including medicine, religion, business, civic affairs, advertising, ecology, law, and acoustics.

With the help of working and advisory panels we have been able to show, as well as tell. For example, we proved that quieter construction noise was possible by importing a quieter portable air compressor and jack-hammer from England, and performed the first public demonstration of quieter construction equipment on American soil. It was after that demonstration that American manufacturers started to place silenced equipment on the market, and what is quite important, actively promote such equipment. CQC also inspired Bethlehem Steel to design the world's first quiet metal garbage can.

It helped the mayor and his commissioners of sanitation and purchases respond favorably when we urged that the city specify quieter operation when it ordered hundreds of new garbage trucks. (The author had observed silenced garbage trucks in operation in Germany when he attended the Fourth International Congress for Noise Abatement in 1966.) Thanks to the added impetus of the Mayor's Task Force for Noise Control, the active interest of the automotive industry was aroused and General Motors won a $4 million contract for a quieter, less air polluting chassis, at a premium of less than $100. There are still some bugs to be ironed out in formalizing the noise specifications, especially for the compactor body, but there is no reason why all American cities should not be able to do away with that chronic nuisance.

SOME REPRESENTATIVE NOISE LEVELS PERMITTED IN THE URBAN ENVIRONMENT

	Decibels	
Large Pneumatic Riveter (3")	125+	Boiler Shop (Maximum Level)
Rock and Roll Band (peak)	120	
Overhead Jet Aircraft (500')	115+	
Loud Motorcycle	110	
Construction Noise (Hammers and Compressors) (10')	110	
Loud Outboard Motor	102	
Subway Train (20')	95+	
Train Whistles (500')	90+	
Heavy Truck (25')	90+	
	40+	Average Residence
	* 32	Room In a Quiet London Dwelling (at Midnight)

* "A" Scale, a modified form of decibel, weighted to emphasize the upper frequencies. All other figures are in the flat or "C" scale.

Compiled by Citizens for a Quieter City, Inc. from government documents, 1969.

The work of an organization such as CQC is only a beginning. Now city government must do the implementing. Once city officials recognize their responsibility to protect the public from excessive noise, they can employ the available tools of anti-noise ordinances, zoning codes, planning, and nuisance regulations. New

York City, much maligned for its noisiness, is developing a prototype for municipal action that should prove useful to all American cities.

The first step Mayor Lindsay took was to set up a Task Force on Noise Control. The Task Force report, shortly to be released, will highlight the nature of the urban noise problem and suggest an action program. At almost the same time, the City established a noise control function to operate under its Department of Air Pollution Control. The recommendations of the Task Force will provide guidance to this pioneer agency in evolving the nation's first municipal noise abatement program.

Assuming a will to abatement, in the final analysis legislation will be necessary to set noise standards for both personal conduct and for industry. Ideally, a model code should be hammered out by a partnership of all levels of government, the concerned citizen, and industry. If the federal government fails to develop a community noise program, it might be desirable for the National League of Cities to initiate its own study of existing domestic and foreign legislation.

Those manufacturers who have voluntarly moved to design quieter equipment deserve the protection of noise legislation. Without it the cheaper, but noisier competitor will retain the market.

Legislation must be aimed at protecting the public, not the current noise levels. Almost every community has an ordinance that prohibits disturbance by barking dogs. These ordinances do not specify the size of the dog or the decibel of the bark. It is accepted that barking disturbs sleep and sleep must be protected. It makes no sense to pick on barking dogs alone, when air conditioners, airplanes, and trucks are exempt from muffling their equally disturbing "bark." Protective ordinances, such as those enacted by Coral Gables and Beverly Hills for air conditioning, should be studied. Legislation should also incorporate incentives for quiet design by restricting the number of hours *during the day* that noisy operations can take place.

In addition to specific anti-noise ordinances, the need for acoustic privacy should be recognized by adopting proper building codes. Though New York City's new noise insulation provisions are no paragons of acoustic virtue—they are lower than European standards, for one thing—it recognizes the principle of keeping decibels out of human living space. It is not practical to have 18,000 individual dwelling noise codes, and national guidelines are indicated. Congress should be asked to implement the recommendations of the President's Science Advisory Council for such guidelines.

It is unlikely that a new baby like noise abatement will receive more than a benign pat on the head from Washington, if that. In the meantime, it is not necessary to let the roaring horsepower continue unabated. Cities should set an example for the private sector by embarking on a program of noise abatement through noise specifications in their own purchase orders. There should be no hesitancy in requesting vendors to supply quieter equipment. Industry buys this way, and so do the armed forces.

The reponsibility for implementing urban noise control falls squarely on the shoulders of city government. To shirk that responsibility is to invite disaster. Air pollution is killing man slowly, excessive noise makes each day a torment. The hovercraft and the SST are around the corner, the short-take-off-and-landing plane (STOL) is being ordained by the FAA for center-city, and we have not even begun to cope with the bus and truck.

There is no other course at this time than an honest partnership between city government, the public, and business. To continue to treat noise complaints with indifference is to alienate the citizen at a time when there are too many other excuses for withdrawing from civic responsibility.

FURTHER READING

Noise—Sound Without Value.—A 56-page report prepared by the Committee on Environmental Quality of the Federal Council for Science and Technology, Sept. 1968. 60 cents.

Noise in Urban and Suburban Areas.—A 52-page report developed under the Technical Studies Program of the Federal Housing Administration, Department of Housing and Urban Development, Jan. 1967. 40 cents.

Both reports are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

[Reprinted from Medical Tribune and Medical News, Jan. 4, 1968]

NOISE POLLUTION: A NEED FOR ACTION

(By Samuel Rosen, M.D.)

Noise levels in the world's urban centers have been rising steadily since the Industrial Revolution. In the United States today, jet and helicopter transport have raised noise pollution to a new peak, and tomorrow the supersonic plane will lift it further. Are noise intensity and chronicity nearing a point where they are become a serious hazard to public health?

Legally as well as medically, intense and steady noise is recognized as an occupational "disease" that can inflict irreversible damage in the form of neural deafness. Nineteen years ago, a United States court awarded compensation to a drop-forge worker who developed occupational presbycusis. Many industries now protect their employees against chronic noise levels in the dangerous range, exceeding 85 to 90 db. The number of workers exposed to excessive factory noise is relatively small, but what of the average city or suburban resident exposed to noise levels which equal or exceed the damage-risk criteria suggested for factories? Many city noises do approach or exceed this limit, producing a crescendo of unwanted noise against which we are helpless and to which we think we are accustomed.

We do not know how much exposure to these intense city noises will cause hearing loss, but the danger is there. At the Central Institute for the Deaf in St. Louis, chinchillas and guinea pigs were exposed to brief, intermitten periods of above-normal—but supposedly tolerable—noise levels. They developed swollen cochlear membranes and obliteration of inner-ear hair cells. Stanford Research Institute studies show that electroencephalographic patterns of sleeping subjects are radically altered by sound levels that do not awaken them. It is known that loud noises cause effects which the recipient cannot control. The blood vessels constrict, the skin pales, the muscles tense, and adrenal hormone is suddenly injected into the blood stream, which increases tension and nervousness.

Levels of presbycusis can be correlated with the environmental sound levels of various populations, and blood nutrition to the ear seems involved in the process. In 1960 I began a series of studies, with a team of investsigators, among the Mabaans, a tribe living in a relatively noise-free environment in southeast Sudan. These tribesmen were surrounded by a village background noise level of below 40 db., and only on rare festival occasions did the noise level reach 110 db. for brief periods. At age 75 their hearing was still acute. Plethysmographic measurements of capillary blood flow changes showed rapid constriction of the blood vessels at loud, unexpected noise, with the flow quickly reestablished. The same rapid capillary constriction occurs in the New York businessman, but recovery is much slower. This would suggest generally impaired nutrition, including that to the ear, during the reflex action. It would seem that loud noise can increase body tensions, which can then affect the blood pressure, the functions of the heart, and nervous system.

The psychic effect of noise is very important. Noise can cause enough emotional response and frustration to make a person feel nervous, irritable, and anxious. Rest, relaxation, and peaceful sleep are interrupted and often denied to those suffering from illness. We now have millions with heart disease, high blood pressure, and emotional illnesses who need protection from the addiitonal stress of noise. We make a great point of keeping our hospitals quiet, but the sudden and repetitive noises of street traffic, construction work, roaring jets, etc., penetrate the hospital walls.

We now recognize the hazards of air pollution and are slowly beginning, at this late date, to attempt some solutions. Physicians and acoustic experts warn against the dangers of noise pollution, and some solutions must be sought before the acceleration of noise becomes too great for effective control. Effective controls are possible. Granting the cost may be high and governmental regulation difficult to achieve, buses, trucks, construction equipment, sanitation trucks, planes, helicopters, street traffic, subways, elevated trains, air conditioners, office machines—all these and many more sources of high-level noise can be made quieter through proper engineering techniques. Acoustical science and technology have provided the Army with an inaudible motor for front-line use, the Navy with silently operating submarines, and the Air Force with an almost silent plane. Surely some of the same techniques applied to civilian use would do much to alleviate the health hazards of excessive noise.

Public pressure could help bring about legislation and its enforcement. All community organizations and others, such as Citizens for a Quieter City, Inc., in New York, should support and aid the cause of reducing noise levels in our environment. As physicians aware of the dangers to the health and well-being of our patients, we should be involved in the campaign against noise pollution.

[Reprinted from Medical Tribune, Jan. 26, 1970]

NOISE STUDIES CONFIRM HAZARD TO ANIMALS, MAN

BUT BENEFIT TO WOMEN: MINK BEAR MORE KITS

The items on this page are reported from the 136th meeting of the American Association for the Advancement of Science, held in Boston.

Silence may or may not be golden, but it certainly is healthful. Or, at any rate, noise is unhealthful, panelists agreed at an A.A.A.S. symposium on the physiologic effects of audible sound.

The din produced by our increasingly mechanized and transistorized life style has been recognized for some time as a distinct environmental pollutant (MEDICAL TRIBUNE Science Report, March 18, 1967). A growing, if scattered, number of studies have even begun to sketch the possibilities of damage that noise could be blamed for.

The full potential of noise's harm to human beings, however, is yet undreamed of because such investigations are only beginning, according to many participants in the two-and-a-half-day program. In the meantime, as in the case of some other environmental pollutants, the indirect evidence accumulating against noise is pushing it into the category of a clear and present danger to a civilization becoming ever more urban.

LITTLE DOUBT ABOUT HAZARD

Dr. Samuel Rosen, consultant to the Mount Sinai School of Medicine in New York and widely known for his audiometric studies of Mabaan tribesmen in the quiet Sudan back-country, concluded that "there seems to be little doubt that noise pollution is a health hazard." Even among the Mabaans, who have a considerable vascular elasticity compared with the people of some other cultures, a permanent move into noisy Khartoum (which also contributes diet changes and stresses other than auditory) produces hypertension, coronary heart disease, and a degree of hearing loss seldom seen in those who stay in the home villages.

Plethysmographic indications of vaso-constriction among the Mabaans and other human being subjected to loud sound, Dr. Rosen said, have since been duplicated in animal studies by other investigators. Cochlear vessel construction in rodents has led to ischemia and loss of sensory cell function. In addition, rabbits stressed with 102 bd. of "white" noise (many frequencies mixed together) have shown a much higher blood cholesterol level than control animals on the same diet. The noise-stressed rabbits also had more aortic atherosclerosis and more cholesterol deposits in the iris.

Dr. Lester W. Sontag, director of the Fels Research Institute at Yellow Springs, Ohio, suggested that the impingement of sharp sounds on the human fetus could do it harm, either by stressing the mother so as to change the intrauterine environment or by overstimulating the fetus itself. He cited a number of his studies to back up both possibilities and then pulled in additional findings that hint a possible relationship of fatal heart rate liability and Moro reflex (both of which can be elicited by sound stimulation) to the eventual behavior patterns of the child.

While Dr. Sontag's discussion was centered principally on the potential danger of sonic booms to unborn children. he also suggested "it might be well to go slow on the diagnositic use of ultrasonic devices and other sound stimuli to assess fetal conditions "in view of our increased knowledge of the vulnerability of the fetus."

Dr. Mary F. Lockett, of the University of Western Australia, discovered that loud noises cause a change in rat hormone secretions, thus increasing water and electrolyte excretion. In addition, she found that the type of hormal dysbalance depended on the pitch of the sound used to stress the rats. A tone of 150 cps, which sound to a human being like a low organ note, made the rats release oxytocin. A very high frequency—20 kcps, which is nearly above the range of human hearing but quite audible to rats, caused the release of epinephrine and a small amount of antidiuretic hormone. All her test sounds had an intensity of 100 db., which is almost the loudness of a boiler factory.

Endocrine responses in man to loud sound were measured by Dr. Amilcar E. Arguelles, of the Argentine Air Force Hospital in Buenos Aires, who exposed normal, hypertensive, postmyocardial-infarction, and schizophrenic subjects to a 2,000-cps pure tone at an intensity of 90db. The Argentine studies confirmed some earlier results obtained elsewhere that noise stimulation elicits a marked epinephrine and norepinephrine rise in peripheral blood, particularly in postinfarction subjects and hypertensives. Dr. Arguelles said the responses were much greater than other researchers had found in subjecting normals and hypertensives to a "mild mental stress," otherwise unspecified.

ANIMALS "PRIMED" BY EXPOSURE

Investigations of "priming" an animal by sound exposure so that it will suffer an audiogenic seizure when the sound is repeated were reported by Kenneth R. Henry, Ph.D., and psychologist associates at University of Wisconsin. Some inbred mice strains are easily plunged into audiogenic seizures, they said, but their work was with a strain not susceptible to such seizures. When these mice were primed with a 103-db startling sound (obtimally at age 16 to 19 days), a repetition of the sound some days later caused convulsions in a high percentage. The same animals showed no increase in susceptibility to electric or chemical stimuli designed to cause seizures, nor could they be similarly primed with these stimuli. Priming with sound, however, proved effective even when the mice were anesthetized. The authors hypothesize that the priming "initiates some highly specific damage" to brain tissue, a damage that needs several days' "incubation" time to become complete enough to produce a high order of susceptibility to the repeated stimulus.

The response of farm animals to noise has been studied in a number of centers, whose general results were presented by James Bond, Ph.D., of the U.S. Department of Agriculture. Dairy cows produce less milk when startled by such sounds as exploding paper bags but show little effects of jet aircraft or sonic boom noises. Observations of behavior in cattle, sheep, and horses failed to disclose any greater amount of startle activity to noise than could have been explained by the presence of a human observer. Sows showed brief startle responses when a din of loud aircraft noise was begun but soon subsided as the sound continued. Their suckling pigs reached the same eventual weight as controls. Dr. Bond also found that "boars and sows were almost entirely indifferent to loud sounds during mating." While other researchers have found that noise will make female mink kill their offspring or let them starve, USDA experiments with sonic booms on mink resulted in slightly greater production of kits by the boomed females than by a control group.

What it all means, said Chauncey Leake, Ph.D., of the University of California Medical Center in San Francisco, is that "much more study must be done—and quickly." The constant background noise in the American home has risen by about 10 db. in the past 50 years, and everything has become noisier outside.

Senator HART. Mr. Baron, I am sure it was intended as a kindness on your part to almost skip read, and what you did read you read very hurriedly. Let me assure you that the thoughts you have here in your prepared statement warrant full and careful exposition. There is no reason really for you to push because all of what you say makes such good sense.

Mr. BARON. Thank you.

Senator HART. You ask somewhat rhetorically, "At what point do we decide to abate as well as to study?" You are suggesting, I take it, that the time is now?

Mr. BARON. I have appeared on television with earmuffs which I use as a symbol of retreat from the environment. It is constantly a shock to me, and a distressing shock, the number of people who write and say, "Where can we buy these earmuffs?"

These are not people who are working in factories, they are people that are working in their homes: a retired priest who wants to be able to sit in his study and read without distraction of traffic outside, housewives and writers and others who want to be able to do whatever it is they want to do without the irritation of the noise level in which they live.

This is all over the country. Noise is not peculiarly an urban problem. I receive many complaints from farmers—noisy tractors, noisy appliances, noisy transportation, suburban areas, and so on. I feel that the term "acoustic anarchy" is not an exaggerated description of the current state of affairs.

Senator HART. That point you make about our longstanding ordinances against barking dogs and yet our seeming acceptance of noise levels far in excess of the dog makes your point.

Mr. BARON. I would like to say in reference to Dr. Sontag's statement about the effect of noise on the human fetus that the West Berlin Health Department, without knowing quite conclusively why, has issued a regulation that pregnant women may not work in noisy occupations. They feel that there is enough known to justify this precautionary measure.

Senator HART. I asked this of Secretary Volpe. The studies are so often aimed at identifying the damage to the fetus or the damage to the physical health and well-being of the community. You would agree, I take it, that we should now begin to put money into the development of the technology and the application of the technology we now have to eliminate the noise. The studies are well and good but we need action. You cite Baden Baden, Germany, where they have reduced noise.

Mr. BARON. In 1966 I attended the Fourth International Conference for Noise Abatement in Baden Baden, Germany, and as a part of that conference we observed the quieter products of various sorts, and one of them was a quieter garbage truck. Noisy garbage trucks, incidentally, are something that people complain about all over the country. We recommended to the city of New York that was then undertaking a large purchase program that if specify quiet design.

Now this is what is interesting. We said, If you ask for quiet, you will get it. The city of New York started a program. It has been of long duration. General Motors, incidentally, is cooperating with the city and has come up with the first quiet garbage truck in the United States, I believe, in which the annoying whine is gone. It is now being field tested. It took a citizen group to observe this in a foreign country and come back and give this information to local government.

The same with the quieter jackhammer and air compressor. We imported a quieter jackhammer and air compressor from England and invited the manufacturers, Congressmen, and others to New York to hear the difference. The first American quieter air compressor appeared a few months later. The problem is not technology, the problem is getting that technology applied.

We talk now about the quality of the environment. Because we do not design for quiet in the home, in the office, in the factory, on the streets, in the parks, excesses of noise emissions are destroying the quality of our environment, if we want to use the latest phrase.

We seek a measureable clinical health effect. We may never be able to find one incidentally, because we may never be able to say that noise is one factor that caused X, Y, and Z. It is very difficult in some cases to isolate the stressor that causes a given reaction. People are suffering. They are finding difficulty in talking, they are kept from sleeping—not necessarily wakened but we now know from studies of sleep cycles that they are kept from having a proper night's rest. Millions of people are being kept from having a proper night's rest with a tool that we will in time begin to understand and which I think is going to be a substantial one.

The invasion of privacy, the fact for example that if you are in your home that you cannot close the door and keep your neighbor out of your home or by the same token to know what whatever you do in the privacy and intimacy of your home is your neighbor's business. I think that this is a very obnoxious and a deleterious situation that in time is going to require us to think in terms of retrofitting homes so that they do offer a certain amount of acoustic privacy. These, I believe, are very serious problems, and I feel that from the imput in my work and from my own personal experience.

Senator HART. May I ask one more question?

Senator RANDOLPH (presiding). Yes.

Senator HART. Traditionally we have always left the problem of noise and the abatement of the noise to the local unit of government and not to suggest that the Federal Government should preempt a local law with respect to noise levels. Do you believe that circumstances now argue that we should look to the Federal Government as the primary point of responsibility for noise and noise abatement?

Mr. BARON. This is my personal feeling. I feel that the Federal Government has a major responsibility because the nature of modern noise is such that it is very difficult for the individual municipality to act against all except what we call the garden variety noises such as dog barking and things of that sort.

Many of the noise sources that are really disturbing people are interstate appliances, lawnmowers, automobiles, aviation. I think that there should be really a partnership between the Federal Government and State and local governments because I know again from my own experience how lacking we are in expertise and advice and guidelines and counseling for local governments that may want to move on noise. They need help.

We have to train a lot of people. I don't believe we have a big enough pool of noise control experts, and I think we should be thinking about that kind of thing. I think that we must expand our concept beyond the neighbor noise source such as the airplane, let's say, or the motor vehicle which is a problem and think of the total problem of the acoustic emissions.

Senator HART. We at the Federal level now have standards for pollution emission control. You say that California and New York have decibel standards but they are not adequate. Do you think the Federal Government should have some decibel standards?

Mr. BARON. I think that the Federal Government should at least develop guidelines. Again I am not an expert in this field but I think that the Federal Government should help by developing guidelines. The decibel standards we have now in New York and California were based on existing noise levels of trucks. I think that if we want to protect the environment to work the other way and say what is the desirable environment in a home, and then work from that toward realistic noise levels.

Also, I cannot foresee the practicality of 50 separate State laws. In terms of industry, I cannot see industry being faced with 50 State decibel levels. So there are, I believe, national guidelines necessary.

Another thing about noise. In the letters I receive from all over the country, in many cases local or State government is not aware of the existence of the problem. In one sense the many people who suffer from noise are a silent majority, they do not complain or their complaints are not heard or rejected. Therefore, I believe that again there are a lot of noise disturbances that could be eliminated if there were a national concern for the overall problem that could be transmitted to State and local governments.

Senator HART. Thank you, Mr. Chairman.

Senator RANDOLPH. Thank you, Senator Hart. Mr. Baron, I want to read your testimony very carefully. I was interrupted of necessity but I will go through your statement because I think Senator Hart has indicated, at least in degree, that we think of the pollution in the air, and of the war, and of solid waste disposal, but there has been perhaps too little interest and attention to noise pollution—the problem of noise. I would not want to live in a world where I could not hear the song of a bird. But I know there is the problem that would be very real to certain people who lived in a tenement wherein elevated trains thundered by every few minutes. I have watched them and heard them in New York City.

I am wondering now how important is the role of public education in noise abatement. How can we proceed to do this job?

Mr. BARON. Well, we are, as you probably know, an educational organization, not a lobbying organization. This is something we have been thinking about quite a bit. One of the strange things about noise, I think one of the reasons we have been slow to move on it is that it consciously affects only a small number of people at any given time. This does not mean that a lot of people are not being disturbed. I think that we must develop an educational program to convey to people the nature of the noise environment in which they are living so that they will support noise abatement programs.

One way we are taking, for example, we have a public service advertising agency and they put out an ad which said in the caption that caught a lot of people's attention. "Noise can't kill, it can only make you deaf or drive you nuts."

One of the reasons we did this kind of advertising is because many people who suffer from noise are ashamed of it. Now this may sound very strange but this is a fact. Many people do not like others to know. They feel it is a sign of weakness or something like that.This is one of the educational problems that I think we must follow, and that is to get people to understand that if they are suffering from noise it is not an illusion.

I think we must try to work out materials, brochures, that explain noise in nontechnical language. I think there has been too much emphasis on the decibel and not enough on the significance of noise as a environmental factor and the various means to control noise.

Incidentally, you might be interested in this. Newsweek, I believe it has been published already, put out an ad on noise abatement. I believe, possibly, this is the first time I know of that a publication has done this on its own. We have radio commercials going in New York now on noise, noise abatement. I believe you are absolutely right that a lot of thought must be given to how the public understands this problem so they will support your efforts because that is part of it now.

Senator RANDOLPH. Just one question, which Senator Hart already has explored with you in part. We know that at the local, State, and Federal levels action must be taken. I am not sure how we can define those areas today. Do you believe with Senator Hart that there must be an emphasis at all levels—Federal, State, and local—or do you feel there must be an overall leadership from the standpoint of the Federal Government with partnership from the other levels of government?

Mr. BARON. I feel that the leadership is necessary. As I say this, however, I think of New York City, which is supposedly one of the noisiest in the country. Mayor Lindsay appointed a task force on noise several years ago. Its report has just been published.

We have set up a Bureau of Noise Abatement under the Air Resources Committee. So New York City is exercising leadership. On the other hand, from where I look at it, if there were a Federal pool of expertise readily available and funds readily available, the city, I believe, could move much faster in the direction of applying noise abatement. It is a pioneering venture and it seems to me that there should be leadership and a great deal of assistance on the Federal level for many reasons, including, as I say, the avoidance of duplication of effort, the accumulating of the necessary research data, the technology, the research on the technology of noise abatement, and so on, many of which are interstate sources.

I believe the Federal Government should develop some sort of noise abatement focus. Noise is a pollutant. I do not even like the word "pollutant" actually, but it is something that is disturbing the environment and disturbing the lives of human beings and we neglected it.

Even the word "noisy" tends to make people smile. When I tell how I got started, five air compressors outside my home for 3 years from 7 o'clock in the morning until 6 o'clock at night, it invariably brings a smile to people. This is what we have to overcome. It is not a joke. I think Dr. Sontag's statement and some of the quotes that I have made and in some of the literature we will find that modern-day noise exposure has caused a great deal more harm psychically and physiologically and so on than we have realized.

Senator RANDOLPH. Mr. Baron, you are a very helpful witness. You are creative and very resourceful in your thinking and in the action of your group. We hope that you will continue to consult with us.

We do have in the Public Works Committee something perhaps a little unique. We have established panels and we are asking the members, who are men and women of expertise in various phases of the environmental program, to talk with us even before legislation is introduced. I think this is helpful. We need to come before the fact rather than after the fact, which happens so often here in our legislative approach. But we cannot help that; we are trying to catch up and to overcome these problems that all mankind has created. Engineering genius has brought upon us many of these problems that we speak of today. I don't deprecate the genius and I don't deprecate progress, but there is a soul of mankind that is to be saved. Isn't this true?

Certainly in all of these discussions we must recognize that a balance within our country's economy with the qualities of life is very, very important. I am grateful, and I know Senator Hart is, for your discussion with us and for your very constructive presentation.

Thank you very much, Mr. Baron.

Mr. BARON. Thank you for the privilege of being here.

Senator RANDOLPH. I may also mention before we close that additional information for the record will be accepted and included for the next several weeks.

(The following materials were subsequently received:)

THE LIBRARY OF CONGRESS,
LEGISLATIVE REFERENCE SERVICE,
Washington, D.C., February 11, 1970.

To: Senate Committee on Public Works. Attention: Mr. Jorling.
From: American Law Division.
Subject: Major Legal Theories Found In Noise Cases.

This memorandum is submitted in response to your request for a survey of recent case law involving noise injury to determine on what legal theories such are based. You have also requested copies of any cases found in which names or testimony of experts in the field of noise have been cited.

Cases involving noise, either as a primary factor or more often involved with other considerations, do not easily lend themselves in all instances to ready classification based upon the cause of action involved. Perhaps, the best classification would be not by the theory upon which the action has been based but rather on the type of noise involved, e.g., animals, automobiles, railroads, aircraft, or construction. Other related matters may also have some important effects on the legal problem of noise, e.g., zoning. However, discounting any criminal actions for violations of laws or ordinances dealing with noise, the bulk of recent civil cases (not all could be studied) seem to fall within three major groups: Nuisance; occupational deafness; and inverse condemnation.

Before commencing a discussion of some of the case law in each of the three areas mentioned above, it should be noted that there are two recent extensive composites of materials on the subject of noise pollution that have been placed in the Congressional Record, including items from experts on the subject of noise. *See*, 114 Cong. Rec. 16413–16470, 29523–29561 (remarks of Representative Kupferman). Also of noteworthy interest is the recent insertion in the Congressional Record of an article by James J. Kaufman, *The Legal Aspects of Noise Control*, 115 Cong. Rec. E9031–E9112 (daily ed. October 29, 1969). A compilation of State and local ordinances is contained therein.

For your additional information, enclosed herewith is a recent law review article on this subject: Spater: *Noise and the Law*, 63 Mich. L. Rev. 1373 (1965). Also enclosed in a multilithed report prepared by the American Law Division of the Legislative Reference Service on *Aviation Noise* (August 14, 1968).

With respect to laws or ordinances, a recent case which may be of interest concerned an ordinance which prohibited, *inter alia*, the making, aiding, countenancing or assisting in making any "improper noise" held that such was vague, indefinite and overbroad and therefore unconstitutional.

> . . . What is an "improper noise?" The dictionary defines "improper" in part as "not in accordance with fact, truth or right procedure," and "not in accord with propriety, modesty, good taste or good manners." The definition of "noise" includes loud, confused or senseless shouting," "sound or a sound that lacks agreeable musical quality or is noticeably loud, harsh or discordant," "any sound that is undesired or that interferes with some-

> thing to which one is listening," or even alternatively "sound or a sound that is not regarded as unpleasing or that has a pleasing melodious quality" as, for example, "the noise of heavenly choirs."
>
> The number of sounds which are constitutionally permitted and protected and which would fall within the proscription of "improper noise" is infinite. Political campaigns, athletic events, public meetings and a host of other activities produce loud, confused or senseless shouting not in accord with fact, truth or right procedure to say nothing of not in accord with propriety, modesty, good taste or good manners. The happy cacophony of democracy would be stilled if all "improper noises" in the normal meaning of the term were suppressed.
>
> The Supreme Court has held on several occasions that statutes or ordinances prohibiting "noise" are valid only to the extent that they are necessary to the protection of other important public interests, e.g., the prohibition of horn blowing or other noise in a hospital zone. Prohibition of "noise" per se is unconstitutional. And the addition of the vague and indefinite adjective "improper" does not cure the defect.
>
> Not only is making, aiding or assisting in the making of an improper noise a crime, but it is likewise a crime to "countenance" the making of such a noise by a third party. The literal language would apparently create a duty on all persons in the vicinity of one making an improper noise at least to attempt to effect a termination thereof. If the citizenry took this duty seriously, it staggers the imagination to contemplate the result. There would be more action in the stands than on the field at any athletic event as spectators sought to protect themselves from violating the law against countenancing the improper noises being made by others about them.
>
> *Landry* v. *Daley*, 280 F. Supp. 968, 970 (N.D. Ill. 1968), appeal dismissed 393 U.S. 220 (1968).

NUISANCE

Generally, noise is not a nuisance *per se* for it is recognized that no one is entitled to absolute quiet in the enjoyment of his property but may only insist upon a degree of quietness consistent with the standard of comfort prevailing in the locality in which he dwells or has his business. However, noise may constitute a nuisance in fact even though it arises from the operation of a factory, industrial plant or other lawful business or occupation. The test in such cases is whether rights of property, of health or of comfort are so injuriously affected by the noise in question that the sufferer is subjected to a loss which goes beyond the reasonable limit imposed upon him by the condition of living, or of holding property, in a particular locality in fact devoted to uses which involve the emission of noise although ordinary care is taken to confine it within reasonable bounds; or in the vicinity of property of another owner who though creating a nuisance is acting with reasonable regard for the rights of those affected by it. *Caldwell* v. *Knox Concrete Products, Inc.*, 391 S.W. 2d 5 (Tenn. 1964).

Therefore, it seems the test for determining whether there is an actionable nuisance, or the threat of an actionable nuisance, where noise accompanies an otherwise lawful pursuit, is a question of fact which depends on the locality; the nature and character of the noise; the degree of intensity and disagreeableness of the sounds; their times, constancy and frequency; and the effect and extent of the inconvenience caused by it, not on peculiar and unusual individuals but on ordinary, normal and reasonable persons of the locality. *Connecticut Bank & Trust Company* v. *Mularik*, 174 A. 2d 128 (Conn. 1961); *Hooks* v. *International Speedways, Inc.*, 140 S.E. 2d 387 (N.C. 1965). Thus, for example, noises which occur during the hours usually devoted to sleep may constitute a nuisance even though this might not be so at other times. *Aldridge* v. *Saxey*, 409 P. 2d 184 (Oreg. 1965).

> Persons living in organized communities must suffer some damage, annoyance, and inconvenience from each other, and the noises arising from normal work-day incidents of the industrial life of a city must be tolerated by all of those who wish to dwell therein.
>
> *Pelletier* v. *Transit-Mix Concrete Corp.*, 174 N.Y. Supp. 2d 794 (Sup. Ct. 1958).

Numerous examples of noises constituting nuisances can be cited. A classic holding that is often cited is that a "musical instrument played loud and long has been held to be a nuisance comparable to the water torture of the Chinese." See

Gorman v. *Sabo*, 122 A. 2d 475 (Md. 1956). Another example is the holding that the operation of diesel trucks was a private nuisance where, in the close quarters between residential properties, the trucks made a loud, nerve-shattering noise, and it was necessary to run them for several minutes before removing them, the trucks operated at 5:45 to 6:00 A.M. and frequently late at night, noxious fumes seeped through the homes, and a loud rumbling noise caused by rolling of the trucks across a weighing scale resulted in vibrations in an adjoining house. *Protokowicz* v. *Lesofski*, 174 A. 2d 385 (N.J. 1961). The Superior Court of New Jersey made the following comment (at 388):

> We cannot shut our eyes to scientific progress, even though it may add somewhat to our individual discomfort. Undoubtedly, the noise of a radio or television set or the explosion of a gasoline-powered engine may, at one time, have been considered a nuisance. Today such interference with our enjoyment of peace and quiet is accepted as a normal minor discomfort which arises with the passage of time and corresponding scientific progress. So here, a diesel motor is part of our scientific development, and ordinarily we must adjust our living habits to noise and fumes of such a motor under ordinary circumstances.

For an idea of the early state of the law on this aspect of the subject, enclosed herewith is Lloyd. *Noise as a Nuisance*, 82 U.Pa.L.Rev. 567 (1934). For a look at a certain type of business being a nuisance, enclosed is Annotation: Automobile Wrecking Yard or Place of Business as Nuisance, A.L.R. 2d 653 (with later case service). The *Caldwell* v. *Knox Concrete Products, Inc.*, 391 S.W. 2d 5 (Tenn. 1965) case is enclosed as it mentions that the testimony of a Mr. R. J. Coker, an industrial sound engineer, was introduced by the defendant at the trial. Likewise, a copy of *Nair* v. *Thaw*, 156 Conn. 445 (1968) is also enclosed because there is discussion of expert testimony at the trial.

OCCUPATIONAL DEAFNESS

A majority of States provide in their workmen's compensation laws for full coverage of all occupational diseases, and would conceivably cover all cases of deafness caused during employment. At least five States have specific provisions dealing with compensation for gradual loss of hearing (Maine—39 M.R.S.A. § 193; Maryland—Md. Ann. Code, Art. 101, § 25A; Missouri—M.R.S. §§ 287.067, 287.197; New York—Workmen's Comp. Law, §§ 49–aa to 49–gg; and Wisconsin—W.S.A. 102.555).

As example of cases in which a claimant was held entitled to workmen's compensation for total or partial loss of hearing incurred on the job, in *Comoletti* v. *Ideal Cement Co.*, 147 So. 2d 711 (La. 1962), it was held that impairment of workman's hearing resulted from an "accident" within the workmen's compensation statute where the impairment resulted suddenly and unexpectedly as the result of exposure to noise of excessive and unusual intensity on a specified date while assisting in firing of a shotgun used to clean the employer's cement kilns. In *Shipman* v. *Employers Mutual Liability Insurance Co.*, 125 S.E. 2d 72 (Ga. 1962), it was held that a claimant who sustained loss of hearing while working on a flight line as a mechanic due to continued and repetitious exposure over a period of months to very loud noises emanating from jet aircraft engines close to his work was entitled to workmen's compensation for loss of hearing, even though he was unable to state upon what particular occasion the engine noises left him bereft of hearing.

Copies of the following two cases are supplied herewith: *Moore* v. *Ford Motor Co.*, 192 N.Y. Supp. 2d 568 (App. Div. 1959) containing mention of medical expert witness, and *Ciavarro* v. *Despatch Shops, Inc.*, 255 N.Y. Supp. 2d 48 (App. Div. 1964) mentioning a special noise study done at the defendant's place of business in 1948.

INVERSE CONDEMNATION

Inverse condemnation has been defined as the popular description of a cause of action against a governmental defendant to recover the value of property which has been taken in fact by the governmental defendant, even though no formal exercise of the power of eminent domain has been attempted by the taking agency. *City of Jacksonville* v. *Schumann*, 167 So. 2d 95 (Fla. 1964).

With regard to aircraft, inverse condemnation enters as a legal theory in the case of overflights and with noise without actual overflight. As to overflights, the courts have held that when regular and frequent flights by Government-owned aircraft over privately owned land at altitudes of less than 500 feet from the surface of the ground constitute a direct, immediate, and substantial interference with the use and enjoyment of the property, there is a taking by the Government of an avigation easement, or easement of flight, in the airspace over the property, and that this taking is compensable under the Fifth Amendment to the Constitution. With regard to other low overflights, but at a height greater than 500 feet, there apparently is no taking of an avigation easement unless such flights interefere substantially with the use and enjoyment of the land. *A. J. Industries, Inc.* v. *United States*, 355 F. 2d 592 (Ct. of Cl. 1966). The courts of at least two States, proceeding under their own constitutions, have permitted recovery in cases where overflights were not involved. *Thornburg* v. *Port of Portland*, 376 P. 2d 100 (Ore. 1962) and *Martin* v. *Port of Seattle*, 391 P. 2d 540 (Wash. 1964). However, these cases do not agree upon the standards to be applied in determining when a taking has occurred, and these cases have been criticized by Spater, *Noise and the Law*, 63 Mich. L. Rev. 1373, 1404–1406 (1965). In fact, such a holding was specifically rejected by the Supreme Court of New Hampshire in *Ferguson* v. *Keene*, 108 N.H. 409 (1968). For a discussion of the facts and law of these two State cases as well as the holdings in the pertinent Supreme Court cases, enclosed is a copy of *City of Jacksonville* v. *Schumann*, 167 So. 2d 95 (Fla. 1964). Also, see the Legislative Reference Service multilith that has been enclosed.

With regard to similar circumstances involving highways, it appears that most State courts hold that where there has been a partial taking of property for highway purposes, the noise element may be considered as one of several factors in determining consequential damages. *Dennison* v. *State of New York*, 22 N.Y. 2d 409, 413 (Ct. of Appeals 1968). When a highway is constructed on land adjacent to that of an owner whose land is not actually taken, the general rule appears to be that he may recover for actual physical damage that may be caused thereby, but the elements of inconvenience resulting from the noises of engines, horn blowing, glare of lights and the like from passing traffic on the highway are not recoverable. *Richmond County* v. *Williams*, 137 S.E. 2d 343 (Ga. 1964). One attempt at creating an exception to this rule has been found. In the case of school property adjoining a highway, where none of the school property had been taken, it has been held that if it can be proven that the incidental inconveniences or annoyances will destroy the beneficial use of the property for educational purposes, recovery can be had. "In such a case justice demands that the right to compensation as well as the amount thereof be determined by the effect of the proposed highway construction upon the school facilities, without regard to whether such construction involves a physical invasion of the property." *Board of Education of Morristown* v. *Palmer*, 212 A. 2d 564, 571 (N.J. 1965). On appeal, however, this case was reversed on the ground that the issue was hypothetical and that the effect on the school until the highway would be constructed was purely speculative. Thus, the action was held to be premature, although the appellate court was clear to state that it was expressing no view on the issue of liability, and it dismissed the case without prejudice so that the Board could bring the action again at a later time. *Board of Education of Morristown* v. *Palmer*, 218 A. 2d 153 (N.J. 1966).

Daniel Hill Zafren,
Legislative Attorney.

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Aviation Noise

A SURVEY OF BACKGROUND AND LEGAL PROBLEMS

(By Julia L. Sayles, Legislative Attorney, American Law Division, August 14, 1968)

INTRODUCTION

Sleep is disturbed. Conversation is impaired. Dishes rattle. Walls vibrate.[1] A school board votes additional funds to purchase insulation to protect against noise from a neighboring airport.[2] The President halts all flights along the Potomac River to assure his speech will be heard by those gathered at the Lincoln Memorial in tribute to the poet, Carl Sandburg.[3]

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[1] *Highland Park, Inc.* v. *United States*, 161 F. Supp., 597, 599 (Ct. Cl. 1958) after reciting the fact that 30 to 60 jets flew over plaintiff's property each day the court in this case stated: "when they passed over the property, all conversation had to cease, radio and television reception was disrupted, the windows in the house shook, dishes rattled on the shelves, sleep was disrupted, and the noise was so great as to the painful to the ears of some of the residents. Some were in a constant state of anxiety, and had to undergo medical care for nervous disorders, said to have been induced by anxiety over the passage above their homes of these jets."

While more millions each year enjoy the benefits of jet travel, an increasing number of persons, particularly those living near large airports, are suffering from a by-product of this technological advancement—jet noise. As their number increases, greater and greater pressure is being brought to bear on both the Courts and the Congress in an effort to reconcile these conflicting interests.

It is with this process of accommodation that this paper deals, first, through a review of the earliest adjustments to the aircraft itself as well as the accompanying noise, and second, through a review of more recent cases finding at least temporary solutions by invocation of such traditional legal theories as eminent domain, trespass, nuisance and, to a limited extent, negligence. In addition to this review of the judicial treatment of the problem we shall also concern ourselves with Congressional attention to date including a review of various types of proposals presently before both Houses. And because a great deal of the Congressional effort to date has been limited to a delegation of particular functions to regulatory agencies, particularly the Federal Aviation Administration and the Civil Aeronautics Board, we shall consider their respective areas of jurisdiction.

A. Legal Concepts Yield to the Air Age

Prior to the flight of Kitty Hawk, our real property law had adopted the Roman maxim, *cujus est solum ejus est usque ad coelum.*[4] The property owner, the early courts said, was entitled to complete and unimpaired use of the air space above his land, a right which protected him from overhanging eaves and cornices,[5] overhanging branches [6] and obtrusive telephone poles and wires.[7]

A concept that protected a property owner from an intrusion by overhanging eaves was—arguably, at least—incompatible with notions of air travel. The limitations of this concept, however, were suggested at least as early as 1815 when Lord Ellenborough in a much-quoted English case stated:

> I do not think it a trespass to interfere with the column of air superincumbent on the close. . . . But I am by no means prepared to say that firing across a field in vacuo, no parts of the contents touching it, amounts to a clausum fregit. Nay, if this board overhanging the plaintiff's garden be a trespass, *it would follow that an aeronaut is liable to an action of trespass quare clausum fregit at the suit of the occupier of every field over which his balloon passes in the course of voyage.*[8] [Emphasis added]

Though, as this language indicates, its possible limitations were then recognized, if ony hypothetically, the maxim was not actually threatened until it was clear that the airplane was a reality or, put in practical terms, until the operation of this then primitive machine had become an annoyance to some landowner.[9]

Much concern, however, was shown by the academicians, as evidenced by the flurry of writing in this early period.[10]

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[2] *Washington Post*, February 24, 1967, p. B–4.

[3] New York Times Magazine, January 14, 1968, p. 24.

[4] "Whose is the Soil, his it is up to the sky." While this maximum is generally attributed to the Romans, in particular, a glossator or commentor on the Code, Accursius, there is some doubt that it was actually a part of Roman law. See Hugin, Airspace Rights and Liabilities as Affected by Aircraft Operation, 26 Notre Dame Lawyer, 620 (1951).

[5] *Aiken* v. *Benedict*, 39 Barb. 400 (N.Y. 1863).

[6] *Countryman* v. *Lightbill*, 24 Hun. 405 (N.Y. 1881).

[7] In *Butler* v. *Frontier Telephone Co.*, 186 N.Y. 486. 79 N.E. 716 (1906).

[8] *Pickering* v. *Rudd*, 4 Comp. 219, 171 Eng. Rep. 70, 71 (N.P. 1815).

[9] See, in this regard, *Portland Harbor Land and Hotel Co.* v. *United States*, 260 U.S. 327 (1922) in which the court held that the shooting of guns across plaintiff's land constituted a trespass.

[10] Evidencing this intensified concern are the many law review articles on this subject between 1915 and 1935. Of interest with regard to this early period are: Zollman, Airspace Rights, 53 Am. L. Rev. 711 (1919) ; Carthew, Aviation, Its Future and Legal Problem, 63 Sol. J. 418 (1919) ; McCracken, Air Law, 57 Am. L. Rev. 97 (1923). Trabue, The Law of Aviation, 58 Am. L. Rev. 65 (1924) ; Platt, The Airship as a Trespasser, 7 Ohio Rev. 402 (1909).

With the rapid development of air transportation that followed World War I, what had been merely a more or less academic debate became a problem needing immediate attention. Some, relying on the Roman maxim, argued that the only solution was to be found in condemnation of the air space, or, if that was impracticable, in ratification of a constitutional amendment to remove the impediment so as to assure fullest use of the airways. Taking the position that condemnation was necessary, Major Elza C. Johnson, speaking in 1921 for the Solicitor of the Department of Commerce, stated:

> The navigation of the air must depend entirely upon the question of who owns the airspace above. If the common law rule is recognized, that space above the earth belongs to the owner of the earth, then no power exists in the Constitution of either the state or nation to deprive he individual owner of any rights to free use and occupancy of that space as long as he does not molest the private ownership of his neighbors. No one has the right to cross his property with an airplane and trespass upon his right to enjoy without danger or fear of danger . . .[11]

He then recommended, consistent with his understanding, that the government take steps to obtain the use of this air space.[12]

In the same year, the American Bar Association's Special Committee on the Law of Aviation, although also recommending a constitutional amendment, nevertheless disagreed with Johnson's understanding of the law. They said:

> We submit that it should be the law that it is not an invasion of private rights to utilize the air over land for passage by flight, if such flight is accomplished without jeopardizing any right heretofore usually beneficially enjoyed in the ownership of the land; and that the rights of ownership are those benefits which have hitherto been commonly recognized as incident to such ownership. We feel that this committee can do no more beneficial service to the public and the common interests of all of our people than to challenge that it is an invasion of the rights of private ownership of property to utilize air for purposes of flight.[13]

The next year, however, the committee decided that a constitutional amendment was not necessary and withdrew its earlier recommendation.[14]

While the debate continued among the legal writers and bar association committees, state and federal legislatures were likewise involved in attempting to find solutions to this problem. By 1922, the National Conference of Commissioners on Uniform State Laws adopted a "Uniform State Law of Aeronautics," which in part, provided:

> Sec. 3 *Ownership of Space*
>
> The ownership of space above the lands and waters of this state is declared to be vested in the several owners of the surface beneath, subject to the right of flight described in Section 4.
>
> Sec. 4 *Lawfulness of Flight*
>
> Flight in aircraft over lands and waters of this state is lawful unless at such a low altitude as to interfere with the then existing use to which the land or water or surface over the land or water is put by the owner, or unless so conducted as to be imminently dangerous to persons or property lawfully on land or water beneath.[15]

Thus it would appear that the uniform act, which was adopted by 22 states,[16] while modifying the old maxim did not actually abandon it. By 1932, at a joint meeting of the American Bar Association and the Commissioners on Uniform State Laws, it was decided that these sections were no longer in keeping with the development of air travel.[17] It was not until 1943, however, that the Commissioners formally withdrew them from the Uniform Act.[18]

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[11] 2 Air Service Information Circular 13 (1921).

[12] *Id.*

[13] 46 A.B.A. Rep. 498, 515 (1921).

[14] 47 A.B.A. Rep. 413, 415 (1922). The Committee indicated it wished Congressional action and subsequent court review. It felt its earlier proposal would only delay this process.

[15] Handbook of the National Conference of the Commissioners on Uniform State Laws 166 (1928).

[16] Ariz., Del., Ga., Idaho, Ind., Md., Mich., Minn., Mo., Mont., Nebr., N.J., N.C., N. Dak., Pa., R.I., S.C., S. Dak., Tenn., Utah, Vt., and Wis.

[17] 57 A.B.A. Rep. 138, 368 (1932).

[18] Handbook of the National Conference of Commissioners on Uniform State Laws 66–67 (1943).

Congress, during this same period, was anxious to put itself on record as fostering air transportation. Believing that European aviation was advancing at a rate in excess of that in the United States,[19] Congress in 1926 passed legislation to remove what it felt were major impediments to the rapid development of this industry.[20] Primarily concerned with safety regulations, this legislation did, in Section 10, define "navigable airspace," not really for the purpose of defining what airspace, if any, could be said to be in the public domain and thus available for air navigation, but to implement the then grant of authority to the Department of Commerce to set minimum safe altitudes for flights over congested and noncongested areas. Yet, as the subsequent review of court decisions will indicate, this section, including the regulations promulgated pursuant to it, has served as a guideline separating public airspace, that available for air travel, from private airspace, that necessary for the use and enjoyment of the landowner. Specifically, Congress provided:

> As used in this Act, the term "navigate airspace" means airspace above the minimum safe altitudes of flights prescribed by the Secretary of Commerce under Section 3, [that section which outlines the Secretary of Commerce's regulating authority] and such navigable airspace shall be subject to a public right of freedom in conformity with the requirements of the Act.[21]

Though aviation has considerably advanced from that familiar to the Congress in 1926, this section remains virtually intact with the exception of an amendment in 1958 designed to include, within the definition of navigable airspace, that airspace reasonably necessary for "safety in the takeoff and landing of aircraft.[22]

Operating pursuant to the statutory mandate, the Secretary of Commerce in 1926 provided that air tarffic must retain altitudes of at least 1000 feet above congested areas and at least 500 feet elsewhere.[23]

B. Judicial Consideration of the Noise Problem

1. The Injunction.

As the academicians concerned themselves with problems relating to the old Roman maxim mentioned above, airports were built in once vacant fields. Quiet farm communities familiar with no noise louder than of their own labor were becoming runway communities for neighboring metropolitan areas. As the frequency of landings and takeoffs increased, residents became restless, to the point of instituting litigation to alleviate, if they could not eliminate, this alleged intrusion.

First to bring such an action was a resident of a sleepy Ohio community within fifteen miles of Cleveland. He alleged that prior to 1929 he had constructed residences on a 135-acre site. When he heard that Curtiss Airports Corporation intended to purchase an adjacent 272-acre site for the construction of a private airport, he notified the company that such a use was incompatible with his prior established use. The company, however, proceeded with its plans. Shortly thereafter, the plaintiff brought an action to enjoin the operation of the airfield, alleging, first, that such an operation would so materially interfere with existing uses as to constitute an abatable nuisance; and, second, that flying above his property constituted a trespass and as it would be a recurring event, it should be enjoined.[24]

With regard to the second contention, that an overflight constitutes a trespass, the court stated:

> . . . we cannot hold that in every case it is a trespass against the owner of the soil to fly an aeroplane through the airspace overlying the surface. This does not mean that the owner of the surface has no right at all in the airspace over his land. He has a dominant right of occupancy for purposes incident to his use and enjoyment of the surface, and there may be such a continuous and permanent use of the lower stratum which he may reasonably expect to use or occupy himself as to impose a servitude upon his use and enjoyment of the surface.

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[19] See S. Rept. No. 2, 69th Congress, 1st Session in which the Senate Committee on Commerce expresses concern that the country which was the father of aviation was not developing adequate programs to encourage growth of this industry.

[20] Air Commerce Act of 1926, 44 Stat. 568 (1926).

[21] *Id.* at 574.

[22] Federal Aviation Act of 1958 § 101 (24), 72 Stat. 737 (1958).

[23] See, today, 14 CFR 91–79.

[24] *Swetland v. Curtiss Airports Corporation*, 41 F. 2d 929 (N.D. Ohio 1930) Aff'd 55 F. 2d 201 (6th Cir. 1932).

Later the court continued:

> As to the upper stratum which he may not reasonably expect to occupy, he has no right, it seems to us, except to prevent the use of it by others to the extent of an unreasonable interference with his complete enjoyment of the surface. His remedy for the latter use, we think, is an action for nuisance and not trespass. We cannot fix a definite and unvarying height below which the surface owner may reasonable expect to occupy the air space for himself. that height is to be determined upon the particular facts of each case. It is sufficient for this case that the flying of the defendants over the plaintiff's property was not within the zone of such expected use. We think the question is unaffected by the regulation promulgated by the Department of Commerce, under the Air Commerce Act of 1926 (49 USCA § 171 et seq.), and adopted by the state of Ohio, requiring aeronauts to fly in rural sections at a height not less than 500 feet above the surface, for in our view that regulation does not determine the rights of the surface owner, either as to trespass or nuisance.[25]

Concluding, as the court did, that the defendant's use was not such a use as to constitute a trespass, the court went on to consider whether it was actionable in nuisance.

Concluding from the facts that it was, the court stated:

> We cannot doubt from the evidence in this case that the bright illuminated field with the noises incident to its operation, however careful defendants may be, will unavoidably interfere with, if not destroy, the plaintiff's enjoyment of their property.[26]

The court then enjoined the further construction and future operation of the airfield. No further appeal was taken from this Court of Appeals decision.

2. EMINENT DOMAIN—TRESPASS OR NUISANCE

By 1946, the nation had observed a marked increase in airport construction partially stimulated by the demands of World War II. As farmers' fields became airfields, more and more persons began experiencing the inconveniences of this technological change. One such individual, Thomas Causby, the owner of a chicken farm adjacent to a military airfield, brought suit alleging an unconstitutional taking of his property without just compensation.[27] Unlike the plaintiff in *Swetland* he did not ask to enjoin the use or operation of the airfield but only that the defendant, in this case the United States, be required to compensate the plaintiff for the easement taken, that is, this plainiff alleged that the government, in frequently flying at such low altitudes above his property, had effectively appropriated for its use or taken an easement, a right-of-way over his property, which tended to diminish the use and consequent value of this property without just compensation in derogation of the Fifth Amendment. Supporting his contention, the plaintiff alleged that the guide path to the runways of the airport passed within 83 feet of the ground and 69 feet above his house and 63 feet above his barn. He stated that these flights came so close that they barely cleared the trees, that the noise was startling, and that the glare from the plane lights illuminated the property in the evening. Such conditions, he alleged, had destroyed the property as a chicken farm, many of the chickens having died of fright, and had caused loss of sleep and nervousness to its owners.[28]

Justice Douglas, speaking for the majority of the Supreme Court, quickly rejected the old Roman maxim finding it repugnant to common sense. However, he concluded that general principle did not control this case. The United States, he noted, had conceded that if its flights over the property rendered it uninhabitable, there would be a compensable taking under the Fifth Amendment.

> Though it would be only an easement of flight which was taken, that easement, if permanent and not merely temporary, normally would be equivalent of a fee interest. It would be a definite exercise of complete dominion and control over the surface of the land. The fact that the planes never touched the surface would be as irrelevant as the absence in this day of the feudal livery of seizing on the transfer of real estate. The owner's right to possess and exploit the land—that is to say, his beneficial ownership of it—would be destroyed.[29]

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[25] 55 F. 2d 201, 203 (6th Cir. 1932).
[26] *Id.* at 204.
[27] *United States* v. *Causby,* 328 U.S. 256 (1946).
[28] *Id.* at 258, 259.
[29] *Id.* at 262.

While the court held that the use and enjoyment of plaintiff's land was not completely destroyed, it found the alternative uses for which the land could be used markedly diminished. Emphasizing that the airspace apart from the "immediate reaches" was in the public domain, the Court concluded that a taking occurred only when frequent overflights were a "direct and immediate interference with the enjoyment and use of the land.[30] Concluding that the record was incomplete as to whether the easement was permanent or temporary, the Court remanded the case to the Court of Claims for further consideration.[31]

Causby, as indicated above, was a suit filed in the Court of Claims against the defendant, United States, which was both airport operator and "airline" owner and operator. However, as these are separate functions in the commercial aviation world, subsequent litigation was necessary to determine who, after all, would be responsible for such takings. Was it the airport management, which is responsible for building suitable runways and towers? Or was it the noise-producing airline? Or could it be the United States, which approves the flight path for commercial airlines?

This problem was squarely presented to the United States Supreme Court in *Griggs* v. *Allegheny County*.[32] In that case, plaintiffs, nearby property owners, brought suit against the County of Allegheny, the owner and operator of the airport. Two lower Pennsylvania courts agreed that the county was the offender. They were reversed by the Pennsylvania Supreme Court which suggested that the plaintiffs look to the airlines, the owners of the noise-producing airplanes.[33] As this was in conflict with a Washington case, *Ackerman* v. *Port of Seattle*,[34] which held the airport liable, reasoning that an "adequate approachway is as necessary a part of an airport as the ground on which the airstrip, itself, is constructed," [35] the Supreme Court granted certiorari.

Upon review, the United States Supreme Court agreed with the Washington court. The airport, the court reasoned, had taken easement "in the constitutional sense." [36]

In a dissenting opinion, Justice Black, joined by Justice Frankfurter, expressed the belief that the federal government had taken the easement. While not specifically advancing the Roman maxim, the dissenters noted the Congressional enactments to date, in particular, the Civil Aeronautics Act of 1938, which asserts a "right of freedom of transit in air commerce, through the navigable airspace." [37]
and argued that this, after all, was the taking, thus making the federal government liable. The majority opinion rejected this thinking, stating that the primary responsibility for condemnation of tracts and air easements was with the airport. They argued that the federal government was involved to the extent that it subsidized airport construction pursuant to the Federal Airport Act.[38]

While the *Griggs* case determined to whom plaintiffs should look for relief, it did little to clarify the basic legal concepts. That is, it did not with any finality determine whether the compensation awarded was for noise interference or for airspace invasion or both. Of particular significance in this attempt to understand the actual theory of recovery was the Tenth Circuit Court of Appeals case, *Batten* v. *United States*.[39] In that case, the plaintiff's homes, though adjacent to an Air Force Base and though bothered by noise from the frequent takeoffs and landings from the airport, were not directly under the flight path. Or as the court summarized the problem:

> The novelty in the instant case is that liability is asserted not *because of disturbance in conjunction with any over-flights but because of the noise, vibration, and smoke alone which harass the occupants of nearby properties.*[40] [Emphasis added.]

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[30] *Id.* at 266.

[31] On remand the Court of Claims awarded damages for the destruction of the plaintiff's chickens, the easement then having been abandoned.

[32] 369 U.S. 84 (1962).

[33] *Griggs* v. *Allegheny County*, 402 Pa. 411, 168 A. 2d 123 (1961).

[34] 55 Wash. 2d 400, 348 P. 2d 664 (1960).

[35] *Id.* at 413, 348 P. 2d at 671.

[36] 369 U.S. 84 89 (1962).

[37] Now 72 Stat. 740 (1958), 49 U.S.C. § 1304 (1964).

[38] 60 Stat. 170 (1946).

[39] 306 F. 2d 580 (10th Cir.) ; *cert. denied.* 371 U.S. 955 (1962) ; rehearing denied, 372 U.S. 925 (1963).

[40] *Id.* at 583.

The court rejected the argument that the taking was really due to noise interference. Distinguishing a taking, which involves a physical invasion, from consequential damages which, though not involving a physical invasion, do diminish the value of the property, the court determined that the invasion by lateral sound waves, unless intentionally directed at a particular piece of property, was not such an invasion as to constitute a taking. As the court stated:

> The vibrations which cause the windows and dishes to rattle, the smoke which flows into the homes during the summer months when the wind is from the east, and the noise which intercepts ordinary home activities do interfere with the use and enjoyment of the plaintiffs of their properties. Such interference is not a taking. The damages are no more than a consequence of the operation of the Base and as said in *United States* v. *Willow River Power Co.*, supra, [324 U.S. 499 (1945)] they "may be compensated by legislative authority, not by force of the Constitution alone." As we see the case at hand, the distinctions which the Supreme Court has consistently made between "damages" and "taking" control and compel denial of recovery.[41]

One of the three judges disagreed. In his dissenting opinion he argued that the government could effect a "taking" by indirect interference as well as direct interference. Citing examples in which the government through regulation effected a "taking" he concluded:

> As I reason, the constitutional test in each case is first, whether the asserted interest is one which the law will protect; if so, whether the interference is sufficiently direct, sufficiently peculiar, and of sufficient magnitude to cause us to conclude that fairness and justice, as between the State and the citizen, requires the burden imposed to be borne by the public and not by the individual alone.[42]

Finding in this case the necessary elements for a taking, Chief Judge Murrah, the dissenting judge, concluded that the damage sustained by the plaintiffs was constitutionally compensable.

The federal courts as of this writing continue to adhere to the view that only a direct physical invasion is compensable. Of significance are two recent cases. In one, *Leavell* v. *United States*[43] the plaintiff lived within 2000 feet of an Air Force "jet engine trim pad," a ground level testing area. Evidence was introduced that while the testing program was in operation, noise ranged from 90 to 117 decibels, shaking windows, rattling pictures and dishes and drowning conversation, radio and television and making it nearly impossible to sleep. Relying on *Batten* the court found that though the use and enjoyment of the property had been diminished, there had not been an invasion of the airspace and that there had not been a compensable taking.

Though the federal courts refuse to award compensation where there was no physical invasion of the airspace, a number of state courts have concluded, as Judge Murrah did in *Batten*, that indirect interference is sufficient. First to fully articulate this notion was the Oregon Court in *Thornberg* v. *Portland*.[44] In that case plaintiffs suffered from severe noise from the neighboring airport though their respective properties were not directly beneath the flight path. The court, after specifically rejecting *Batten*, concluded that after all the property was made less desirable, not because its airspace was trespassed but because the noise generated by the airplanes made life miserable. The court, reviewing *Causby*, decided that that Court had interchanged theories of trespass and nuisance. Believing, therefore, that a nuisance alone can be such an invasion of the rights of a possessor as to amount to a taking, the court rejected the more limited trespass notions of *Batten*.

Following the Oregon court, a Washington court rejected the federal court holdings. In *Martin* v. *Port of Seattle*,[45] the court noted, when commenting on the *Causby* and *Griggs* decisions:

> While a direct overflight or invasion in airspace is in fact involved in each case, it is not clear that the reasoning and approach of those cases is so limited. Realistically, it must be conceded that a major part of the damage in either case was engendered by noise and vibration, whether or not accompanied by a physical displacement of air above the property. Thus, in *Causby* the noise which frightened the chickens to a point where that type of ranch-

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[41] *Id.* at 585.
[42] *Id.* at 587.
[43] 234 F. Supp. 734 (EDSC 1964).
[44] 233 Or. 178, 376 P. 2d 100 (1962).
[45] 64 Wash. 2d 309, 391 P. 2d 540 (1964), *cert. denied*, 379 U.S. 989 (1965).

> ing became impossible would presumably be equally inimical to the use of the land whether it came from directly overhead or obliquely from flights through the adjoining airspace of a neighbor. Again, in *Griggs*, the loss of sleep due to noise and vibration was stressed as an important factor in allowing recovery in addition to the forces engendered by the physical passage of the aircraft above as in close proximity to the home. The reliance placed upon the high noise level by the Supreme Court in both decisions, without detectable preoccupation with its angle of incidence, strongly indicates that the holdings are not limited to those instances where the aircraft pass directly overhead.[46]

Based on this reasoning and to a lesser extent on the Washington State Constitution which recognizes just compensation both for a taking and for a damaging of property, the court agreed that all of the plaintiffs, even those not directly below the flight path, had stated a claim upon which relief could be granted. As in the *Batten* case, the United States Supreme Court denied certiorari.

As the larger aircraft with a potential of producing noise in an intensity not yet experienced by the airport's neighbors become operational, the courts will continue to be pressured by the outcry of property owners now too distant from existing airports to be bothered. As the noise corridor widens fewer of the complaining landowners will be able to allege an invasion of their airspace. This being so, we can expect, particularly in federal courts, and with some frequency in the remaining state courts which continue to require a physical invasion, continued litigation to eliminate this requirement from the concept of taking.

3. *Negligence and the Sonic Boom*

Due to the nature of the problem few plaintiffs have couched their pleadings on a theory of negligence. Most, as can be seen from the factual allegatitons above, desire to have full compensation for the easement allegedly taken. However, some plaintiffs, particularly those disturbed by the testing by the United States of military aircraft, have sought damages based on negligence. Of particular significance are those founded on complaints of property damage due to the overflight of supersonic jet aircraft.

The uniqueness both in the quality of the noise produced and in the legal problems created by this latest technological phenomenon seems to compel a separate discussion.

The sonic boom, as this physical phenomenon has become known, is created as the airplane begins to travel at the speed of sound or faster. In earlier model aircraft, the noise is produced by the engine or internal mechanism of the airplane. The high density of noise found to be unpleasant around major airports came from a cumulation both in intensity and frequency of these subsonic engine noises. As indicated by the *Griggs* and subsequent cases, the airport area may be considered as including not only the land area on which the air terminal and landing field is located, but also the larger surrounding bowl-shaped area required for landings and takeoffs. Failure to acquire such easements as are necessary to encompass this latter area give rise, as we have seen above, to actions for just compensation for a taking of the use and enjoyment of such airspace.

The supersonic transport problem is different. In the first place the noise is not generated by the engine alone but by a "pile up" of sound waves which spread out in all directions from the aircraft; these waves, if they are strong enough, reach the ground in a "boom." This boom is first created at the point where the aircraft exceeds the speed of sound and continues with the craft as it continues to fly at supersonic speeds. The strength of the boom varies with the aircraft's altitude, speed, size, weight as well as such atmospheric conditions as air temperature, wind movement, and air moisture.

The "over-pressure," the physical force by-product produced by this phenomenon, is measured in pounds per square foot. An Air Force bomber flying at its maximum speed at 35,000 feet is said to produce an over-pressure of 5 to 7 pounds per square foot. As it is determined that a wind of 30 miles per hour creates a pressure of approximately 5 pounds per square foot, it is said that such a plane would do little more damage than such wind. But the scientists tell us that the effect of this pressure, unlike that produced by the wind which is exerted in one direction, is exerted in all directions, thus effecting a "squeezing" effect, the pressure being suddenly increased on all sides at the same time. Estimates vary considerably as to the amount of overpressure necessary to do physical damage to standing structures. As late as 1966, the Air Force, in response to letters from persons alleging damage due to the boom, claimed that 70 pounds per-square foot was required to damage even the weakest structures.[47] However, the Federal Aviation Agency's Office of Plans has since reported that overpressures of 2 to 2.9 pounds per square foot may cause considerable damage to glass and plaster, while overpressures of 2.9 to 4.9 pounds per-square foot cause widespread window and plaster damage as well as minor structural damage to wallboard frames.[48]

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[46] *Id.* at 316, 545.

Negligence, though of little use in actions involving subsonic aircraft noise, has proved an important theory of recovery in the boom cases. It must be remembered that the earlier subsonic aircraft cases have primarily involved parties living within a few miles of one of our larger airports. The noise, then, which has been responsible for the problem has been that produced by frequent landings and takeoffs rather than more overflight.

Supersonic aircraft, however, produce the sonic boom, which may annoy persons and damage property from overflight alone. While those bothered by subsonic noises have frequently sought redress by way of recovery for the taking of flight easements, many of those alleging irritation or physical damage from supersonic aircraft do not live near airports. And unlike the complainants in cases involving subsonic aircraft, who alleged irritation or physical damage caused by frequent low altitude flight, these complainants may allege irritation and property damage resulting from as few as one flight at altitudes of as high as 30,000 feet. In one case, *Neher* v. *United States*,[49] the plaintiffs alleged damage to their apartment house from supersonic flights on eight specific days in 1962. Evidence indicated that these flights were at speeds of 1200 miles per hour and altitudes of 30,000 to 50,000 feet.[50] The plaintiffs in this action alleged a taking or in the alternative, a failure on the part of the defendant to so plan its flight paths as to avoid just such damage as they alleged occurred.

The court denied recovery based on a Fifth Amendment taking. It indicated that as the lowest altitude of the flight was at 30,000 feet above plaintiffs' property, it could not be said that such a flight was an invasion of their airspace. However, the court indicated that plaintiffs alleged that if it was not the aircraft that invaded the airspace then it was the sound waves and overpressure that did so. In other words, they were asking this court to separate the still intertwined concepts of trespass and nuisance. The court, however, refused, saying only:

> Without the physical invasion by low and frequent flights directly and immediately interfering with the use and enjoyment of the land, these annoyances are not compensable under the Fifth Amendment.[51]

The court cited *Batten* as directly in point.[52]

The second theory upon which the plaintiffs relied was negligence. The Government, citing a number of sonic boom cases in which the courts had denied recovery on the ground only that flying supersonic aircraft was an activity within the discretionary function exception of the Federal Tort Claims Act,[53] argued that this was such a case. This the court rejected, noting that at the pleading stage defendant had, maybe inadvertently, stricken this defense. They rejected the governments' argument that such an exception was jurisdictional and could not be waived. While it is not our purpose here to outline the procedural aspects of each of these cases, this particular problem suggests that should the Government in the future correctly and timely plead this exception, the plaintiffs might well be without this ground for relief also.

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[47] Kelley, Sonic Booms—Ground Damage—Theories of Recovery 32 J. of Air Law and Commerce 596, 597 (1966).

[48] *Id.*

[49] 265 F. Supp. 210 (D. Minn. 1967).

[50] *Id.* at 212.

[51] *Id.* at 216.

[52] *Id.* at 216.

[53] 28 U.S.C. § 2680(a) denies coverage under the Federal Tort Claims Act for claims "based upon the exercise or performance or the failure to exercise or perform a discretionary function or duty on the part of a federal agency or an employee of the Government, whether or not the discretion involved be abused."

For cases denying coverage in sonic boom situations see, in particular, *Huslander* v. *United States*, 234 F. Supp. 1004 (W.D. N.Y. 1964), and *Schwartz* v. *United States* 38 F.R.D. 164 (D.N.D. 1965).

In *Neher*, however, due to the government's failure to plead the discretionary function exception, the court considered the allegation of negligence. Finding that the flights were not in and of themselves negligently performed, the court concluded:

> . . . the testimony does indicate that it would be possible for supersonic corridors to be designated over uninhabited and sparsely populated areas, or over bodies of water. The radar equipment necessary to track the simulated bomb releases during supersonic training flights could be located anywhere as it is readily movable.[54]
>
> The record shows no compelling necessity to plot supersonic corridors on or near permanent bases or populated areas. Thus, I conclude the United States was negligent in designating and using a supersonic corridor over the Minneapolis-St. Paul area during 1962.[55]

The court then determined that while it could not be said that the boom was the proximate cause of the alleged structural damage, it could be said that it was the proximate cause of glass breakage and plaster damage.[56] It then entered judgment based on that finding.[57]

Of interest in this area of negligence is another sonic boom case, *Brown* v. *United States*[58] in which residents of Boston, Massachusetts brought suit in federal court to recover for certain property damage allegedly attributable to the negligent operation of a government airplane at supersonic speeds.

The court, denying recovery, indicated that the plaintiffs had failed to offer evidence as to the standard of care to be observed by pilots flying supersonic aircraft. The plaintiffs had also asked the court to invoke the common law theory, *res ipsa loquitor*, to the sonic boom situation. The court refused stating that while this doctrine may relieve the plaintiff of the proof of specific negligence it does not relieve the plaintiff of the proof of the causal connection between the defendant's instrumentality and the plaintiff's injury.

4. Local Regulation

Though it is hard to believe that today any court would enjoin the operation of an airfield in an uncongested farm community (as the court did in *Swetland* in 1930), a number of communities have themselves attempted, by regulation, to control the flight of noise-producing aircraft over their towns. These attempts have been uniformly unsuccessful. In one, *Allegheny Airlines* v. *Village of Cedarhurst*,[59] the Village adopted an ordinance purporting to forbid air travel at less than 1000 feet above the Village, which was within a mile of the John F. Kennedy Airport. Ten airlines, the Port of New York Authority, the Air Line Pilots Association International and nine airline pilots instituted a suit against the Village asking the court to declare the ordinance unconstitutional. The Civil Aeronautics Board intervened as plaintiff.

The basic question facing the court was simply whether Congress had preempted the field of control and regulation of commercial aviation or, put in terms of our discussion above, what, if any, airspace below the altitude of 1000 feet had Congress determined to be navigable airspace and thus out of the reach of local control?

The lower court noted the history of congressional control in this area, in particular, the Air Commerce Act of 1926 and the Civil Aeronautics Act of 1938. In both instances, the Court noted, Congress had acted to encourage air transportation as a means of commercial transportation and to assure maximum safety in its operation.

In addition, the court cited congressional acts designed to encourage airport development and growth. Concluding that Congress had a right to regulate air commerce, and that Congress had in fact done so, the court held that local restrictions on the use of airspace were unconstitutional interferences with interstate commerce.

A similar attempt at regulation was made by another of the Kennedy Airport neighbors.[60] This town, Hempstead, N.Y., established a noise tolerance ordinance which set maximum permissible decibels of sound for any mechanism or device creating a noise heard within the town. As in the earlier case, the court enjoined the application of the statute, stating:

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[54] 265 F. Supp. 210, 217 (D. Minn. 1967).

[55] *Id.*

[56] *Id.* at 217, 218.

[57] *Id.* at 218.

[58] 230 F. Supp. 774 (D. Mass. 1964).

[59] 132 F. Supp. 871 (E.D. N.Y. 1955) affirmed 238 F. 2d 812 (2nd Cir. 1956).

[60] *American Airlines* v. *Town of Hempstead,* 272 F. Supp. 220 (E.D.N.Y. 1967).

Local initiative in noise control of aviation is inherently an effort to regulate a consequence while disclaiming regulation of the cause. It cannot coexist with a comprehensive system of federal regulation of aircraft manufacture (through certificates of air worthiness) and federal regulation of air navigation and air traffic.[61]

While, as seen above, some communities attempted by ordinance to alleviate if not altogether eliminate the overhead noise problem, other communities by zoning ordinances attempted to limit the use of property in the vicinity of the airport. For the most part this was tried by way of height limitations.

Ever since the United States Supreme Court in 1909 recognized the height limitation as a permissible exercise of the police power,[62] numerous communities have adopted it for various purposes. With the advent of large scale aviation, many communities, recognizing the bowl-shape character of the landing area, adopted height limitations for the neighboring property. As any exercise of the police power, to be valid, must be found to be a promotion of the public health, safety or welfare, these ordinances were immediately subjected to question. Of particular interest was an Indiana case, *Indiana Toll Road Commission* v. *Jankovich*,[63] in which the state had built a toll road 18½ feet above the ground over 400 feet from the end of a proposed runway in an area restricted to structures no higher than 12 feet.

After stating that the reasonable and ordinary use of airspace above land is a property right which cannot be taken without just compensation, the court determined that the restrictions here did, in fact, amount to a taking and, absent any provision for compensation, were null and void. The court did this only after distinguishing those zoning regulations which merely limit some potential uses as, for example, a requirement that all buildings be set back twenty feet from the road, from those regulations which so limit the permissible area of use or salability of property as to amount to a taking. Relying on *Causby* and *Griggs*, the Court noted the bowl-shape character of the airport landing area and concluded that while such easements were necessary for the landing and taking off of the aircraft, the public airport must compensate the private landowner for using such. Zoning regulations of this character unaccompanied by adequate provision for just compensation are null and void, the court held, making any action, such as this one based on that regulation, likewise invalid.

Certiorari was initially granted by the United States Supreme Court[64] but after reconsideration was denied as improvidently granted.[65] The Court did so after noting that since the result reached in the state court's opinion was based as much on the state constitution as on the federal constitution, a review of the parallel federal question was not necessary. Petitioners had argued that while the Indiana court had relied as much on State as on federal considerations, the opinion was contra to federal policy, in particular, that of the Federal Airport Act.[66] As the court summarized the petitioners' argument, Congress, in passing this statute, had preempted the area in that Congress had thereby made a determination that airport zoning was essential to assure compatible land use in the vicinity of the airport without undue cost. As the Indiana court found such zoning to be null and void, the court, they argued, should consider the federal question.

The majority of the court disagreed, stating that the Indiana court was not saying that all zoning was contra to the state and federal constitution but only that this particular scheme was not acceptable. That being so, the federal Act was not itself drawn into question and thus the court need not consider the larger question. Although the minority did not disagree, they would have preferred to return the case to the Indiana court for a clarification of exactly what was relied on by that court when it declared the ordinance unconstitutional.

In an earlier case, a New Jersey Court found unconstitutional an ordinance limiting the height of structures near an airport to 10 feet, gradually increasing to 370 feet, in order to surround the airport with a two-mile approach area.[67]

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[61] *Id.* at 235.
[62] *Welsh* v. *Swasey*, 214 U.S. 91 (1909).
[63] 244 Ind. 574, 193 NE 2d 237 (1963).
[64] 377 U.S. 942 (1964).
[65] 379 U.S. 487 (1965).
[66] 60 Stat. 170, as amended, 49 U.S.C. § 1101 et seq.
[67] *Yara Engineering Corp.* v. *City of Newark*, 132 NJL 370, 40 A 2d 559 (1945).

In addition, the same landowners were prohibited by the regulation from operating any device which might create electrical interference with airport-to-aircraft radio communication.

One writer indicates that a number of State Attorneys General have expressed the opinion that specific ordinances given them to review do not conflict with state or federal constitutions.[68] As each such review turns on its own facts, a discussion of these opinions, most of which do not include sufficient factual background, will not be undertaken here.

As aviation demands even more space from our airport complexes, more and more communities may attempt, through zoning regulations, to acquire the much-needed easements. Initially these regulations were designed to assure aircraft the minimum physical interference. Lately, however, those proposing regulations have concerned themselves with the noise tolerance of the airport's potential neighbors. As this continues, it seems fair to say such regulations will engender considerable litigations similar to that seen above. Should plaintiffs in other airport noise cases convince the courts that there is some danger from such noise to health and well-being in the vicinity of the airport, it may be asserted that it is a proper exercise of the police power to so limit such developments within the environs of the airport. It should be remembered, however, that any such exercise of this power might well be found to conflict with, and thus be preempted by federal legislation.

C. *Congressional and Administrative Consideration of the Noise Problem*

Though Congress in 1926 concerned itself with the maintenance of minimum safety standards,[69] and in 1938 with economic regulation of the growing air transportation industry,[70] it was not until 1958 that it in any way touched the problem of aircraft noise.[71] In that year, it passed the Federal Aviation Act of 1958 which, among other things, authorized and directed the Federal Aviation Administrator "to prescribe air traffic rules and regulations governing the flight of aircraft, for the navigation, protection, and identification of aircraft, for the protection of persons and property on the ground, and for the efficient utilization of the navigable airspace, including rules as to safe altitudes of flight and rules for the prevention of collision between aircraft, between aircraft and land or water vehicles, and between aircraft and airborne objects." [72]

While this statute seems to be primarily concerned with safety factors, it has served as authority for a number of regulations calculated to minimize noise interference. Operating pursuant to this section the Administrator has established a system of preferential runways: that is, looking at the physical characteristics of each airport, the Administrator has prescribed flight paths which take into account, as well as other safety factors, the comparative congestion of the surrounding areas. In addition, he has required that aircraft climb as quickly as possible and retain specific heights as long as practicable. Similarly, the Administrator has specified what are termed noise abatement turns, a procedure requiring outgoing aircraft, upon attaining a stipulated altitude, to turn away from populated areas instead of continuing on a straight-line climb. And where possible, he has insisted that such climbs be made over bodies of water instead of populated land areas.[73]

Not long after the adoption of the 1958 Act, the Subcommittee on Transportation and Aeronautics of the House Committee on Interstate and Foreign Commerce conducted a series of hearings on the subject of aircraft noise. Testimony was taken from homeowners, airport managers as well as industry representatives. Federal, State and local officials also appeared before the Subcommittee. As indicated in the subsequent full Committee report,[74] most of the testimony consisted of complaints about the disturbances of normal life suffered by people living in the vicinity of our larger airports. The Committee cited such consequences as interruption of school classes and worship services. In particular, the Committee was made aware of the loss of sleep attributed to nighttime flights.

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[68] *Fixel On The Law of Aviation* (4th ed. 1967) § 515 n. 110–114).

[69] Air Commerce Act of 1926, 44 Stat. 568 (1926).

[70] Civil Aeronautics Act, 52 Stat. 973 (1938).

[71] 72 Stat. 731 (1958).

[72] 72 Stat. 731, 750 (1958).

[73] See generally any of the numerous articles discussing this problem included in the study of the Office of Science and Technology of the Executive Office of the President, *Alleviation of Jet Aircraft Noise Near Airports, A Report of the Jet Aircraft Noise Panel*, March 1966.

[74] H. Rep. No. 36, 88th Congress, 1st Session (1963), p. 2.

Following these hearings, the Committee urged passage of a Resolution [75] authorizing the Committee to conduct a full investigation of this problem.

Operating pursuant to this Resolution, passed August 23, 1961, the Subcommittee considered testimony from representatives of the scientific community, the federal agencies involved in research related to the problem, as well as from persons living in the vicinity of the airports. The Committee concluded, however, that while this was a problem needing immediate solution, it would defer to local governmental authorities to exercise their authority under the police power to control unreasonable noise interference. As seen above, the courts, as indicated in the *Cedarhurst* and *Hempstead* cases, have found this method incompatible with the existence of the Federal program. It should be noted that in the 1955 *Cedarhurst* case was available for the Committee's consideration. In its report, however, the Committee specifically rejected the notion that this decision barred all local regulation.[76] The subsequent case arising out of the *Hempstead* situation, not then available to the Subcommittee of course, would seem to preclude such regulation if that case were to continue to represent the applicable law.

The Subcommittee also recommended that the Federal Aviation Administration continue to finance research designed to alleviate the problem.[77] It requested that this Agency, when reviewing the projected expansion plans of existing airports, consider the advisability of requiring each airport operator to procure avigational easements over land lying under the takeoff and landing paths. With respect to future airports, the Committee recommended "the imposition or purchase of avigational easements some distance beyond the airport boundary" and "the inclusion of avigational easements in local zoning ordinances pertaining to clear zones for navigation." [78]

In conclusion, the Committee stated:

> Should the authority of the Federal Aviation Administration to promulgate air traffic rules which seek to alleviate the impact of aircraft noise on persons or property on the ground be found by him to be inadequate, he should report this fact to Congress and seek whatever additional authority is necessary to achieve that end.[79]

Though the Committee failed to recommend specific legislative steps at that time, Congressional interest for a legislative attempt at a solution remained high.[80] In 1965 and 1966, those Congressmen who had long advocated more active Federal participation in the solution of the problem acquired new support from President Johnson. In October of 1965, the President established a panel of experts to review the economic, legal, and medical problems, as well as the available technological know-how.[81] The panel members each submitted a paper outlining the problem from the perspective of his specialty. After a one-day conference, the group agreed that additional research was necessary. They were not optimistic about a purely technological solution to the problem, as the governmental and private research already completed indicated that while it was possible greatly to suppress the noise of an exhaust jet, the costs of such suppression without loss of speed made it unrealizable. That is, while a mechanical device might be made which would reduce noise, it would so substantially reduce the thrust and thus the speed of the airplane as to minimize its value as a "jet speed" aircraft. This general pessimism led the panel to conclude that solutions must be found in some combination of available governmental tools, by means of condemnation authority and fully exercised police powers brought about with financial assistance by the Federal and State governments.[82]

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[75] H. Res. 420, 87th Congress, 2d Session (1961).

[76] H. Rep. No. 36, 88th Congress, 1st Session (1963), p. 22.

[77] *Id.* at p. 28.

[78] *Id.* at p. 29.

[79] *Id.* at p. 28.

[80] Evidence of this concern can be seen in the number of bills submitted in the 88th and 89th Congresses. See, with regard to the 88th Congress: S. 825, H.R. 577, H.R. 920, H.R. 921, H.R. 2066, H.R. 2401, H.R. 2405, H.R. 2406, H.R. 2463, H.R. 2464, H.R. 3286, H.R. 3342, H.R. 3915, H.R. 5926, H.R. 7984, H.R. 8044, H.R. 8082. See, with regard to the 89th Congress: H.R. 588, H.R. 669, H.R. 670, H.R. 2086, H.R. 4962, H.R. 5658, H.R. 5659, H.R. 5660, H.R. 5661, H.R. 7981, H.R. 7982, H.R. 7983, H.R. 9849, H.R. 11340, H.R. 11473, H.R. 11482.

[81] See the report prepared by this panel: Office of Science and Technology, Executive Office of the President, *Alleviation of Jet Aircraft Noise Near Airports, A Report of the Jet Aircraft Noise Panel*, March 1966.

[82] *Id.* at p. 7.

Following the work of this panel, the President, in his message to Congress urging the formation of a Department of Transportation, again recognized the problem of aircraft noise. He stated that he was that day directing the President's Science Adviser to work with the Administrators of the Federal Aviation Agency and the National Aeronautics and Space Administration, and the Secretaries of Commerce and of Housing and Urban Development, to frame an action program to attack the problem.[83] Specifically, he stated that this group's study would include the development of noise standards and the compatible uses of land near airports. Based on its findings, it was to recommend legislative or administrative actions.[84]

This Task Force, since September 1, 1967 under the direction of the Department of Transportation, has made no final report, though it has apparently begun research in the areas recommended.[85] While no over-all report has been issued, the Task Force has submitted for Congressional consideration a bill designed to expand the Federal Aviation Administration's authority with regard to the certification of aircraft. As amended by the House Committee on Interstate and Foreign Commerce, this bill [86] would require the Administrator of the Federal Aviation Administration, after consultation with the Secretary of Transportation, to prescribe standards for the measurement of aircraft noise and sonic boom and to promulgate any necessary rules and regulations to provide for their control and abatement.

In addition, the Administrator would be directed to apply standards, rules and regulations in certificating with respect to types of aircraft and aircraft engines and propellers, and the issuance of production, airworthiness, air-carrier operating and airman certificates, which would take into account the data available to him on the noise subject, and he would be required to consult, in that connection, with the appropriate federal, state and interstate agencies, and consider economic reasonableness and technological practicability of any proposed standard, rule or regulation in this area. In doing so, he would also consider whether any such standard, rule or regulation is consistent with necessary safety standards. It was this last factor which induced the House Committee on Interstate and Foreign Commerce to amend the original Administration proposal which would have placed the regulatory authority in the hands of the Secretary of Transportation instead of the Administrator of the Federal Aviation Administration. The Committee believed that as the Administrator already had the responsibility of issuing safety compliance certificates, he ought to be the one, after consultation with the Secretary of Transportation, to issue noise compliance certificates as well.[87]

The bill, as amended, passed the House 312 to 0.[88] An amendment which would have prohibited the overland flights of supersonic aircraft until the Administrator of the Federal Aviation Administration had been satisfied that the problem of sonic boom had been solved and its effects had been controlled was defeated.[89]

Senate consideration of the measure was also without apparent dissent, passing without amendment on a voice vote.[90] An amendment[91] which would have prohibited nonmilitary aircraft not involved in a testing program from flying over the United States or its possessions for a period of two years, during which time the Administrator of the Federal Aviation Administration would have conducted studies to determine the potential physiological and psychological effects of frequent exposure to sonic booms and their potential effect on physical structures, in particular, objects of natural or historical significance, was defeated.[92]

The measure was signed by the President on July 21, 1968.[93]

While it is too soon to assess the value of this enactment it is unlikely completely to solve many of the legal problems previously discussed. As industry officials today estimate that new design can only eliminate, at the most, approximately twenty decibels or only about one-sixth of the noise produced by the large jets already in operation, and as these same spokesmen expect that the newer and larger planes will, even with modification, make as much or more noise than those already in service, the measure, in the industry's opinion at least, does not appear to offer much hope of relief.[94]

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[83] 112 Cong. Rec. 4546, 89th Cong. 2nd Session (1966).

[84] *Id.*

[85] See testimony of Secretary Boyd, Hearings on H.R. 3400, H.R. 14146 before the Subcommittee on Transportation and Aeronautics of the House Committee on Interstate and Foreign Commerce, 90th Congress 1st and 2nd Sessions, at 73 (1967).

[86] H.R. 3400, 90th Congress, 1st Session (1967).

[87] H. Rept. 1463, 90th Congress, 2nd Session (1968), p. 5.

[88] 114 Cong. Rec., H4718 (Daily Ed. 1968).

[89] *Id.*

[90] 114 Cong. Rec. S8536 (Daily Ed. 1968).

[91] 114 Cong. Rec. S8523 (Daily Ed. 1968). It should be noted that this amendment, introduced by Senator Case, was substantially the same as S. 3399, introduced by him on April 29, 1968, of the 90th Congerss, 2nd Session.

[92] 114 Cong. Rec. S8538 (Daily Ed. 1968).

[93] P.L. 90–411.

Other factors mitigate against any decrease in pertinent litigations in the near future. One, in particular, is the recent interest by citizens' groups to intervene in the Civil Aeronautic Board's certification and route proceedings in order to express their opinions on the selection of a particular route. Encouraged by the success of conservation groups which have intervened in the certification proceedings of the Federal Power Commission, to argue non-economic considerations, in one case, that the proposed facility on scenic Storm King Mountain would ruin the scenic value of the mountain, would require the running of overhead transmission lines through neighboring towns, and would have an adverse effect on fishlife as well as vegetation of the area as well as open the area to industrialization,[95] these groups are now seeking to require the Civil Aeronautics Board to broaden its consideration of route certification to consider similar non-economic matters. As the Supreme Court stated in a similar case involving the grant by the Federal Power Commission of a license to a private company to develop the Snake River dam site:

> The test is whether the project will be in the public interest. And that determination can be made only after an exploration of *all issues relevant to the "public interest,"* including future power demand and supply, alternate sources of power, the public interest in preserving reaches of wild rivers and wilderness areas, the preservation of fish for commercial and recreational purposes and the protection of wildlife.[96] [Emphasis added.]

While to date no one has successfully litigated the proposition that noise factors are essential considerations in an air route certification proceeding, litigants may be encouraged by the position taken by the Department of Transportation that such factors as noise should be considered.[97]

Conclusion

While the virtues of jet air travel continue to be applauded the inconveniences brought about by it, particularly to the airport's neighbors, have to date and should continue in the future to demand considerable attention from the courts, the regulatory agencies and the legislative bodies. With the increase in the number of airports equipped to accept jet aircraft, with the increase in the number of aircraft landing and taking off from those airports which already have jet service, and with the increase in noise predicted to be a by-product of the future and larger airplanes now on the drawing boards, we can expect that disturbed persons will demand a larger part in each phase of this process of accommodation. Although, it seems fair to conclude, few will succeed in enjoining the operation of an airport, many will seek a voice in proceedings relating to decisions to extend runways, to increase air service from a particular airport, or to route or reroute air traffic. Many will also ask that airports acquire their adjacent and most affected land area. And as they have in the past, many will seek just compensation for the alleged taking of their property.

NOISE AND THE LAW

(By George A. Spater*)

I. ABOUT SOME ANCIENT NOISES AND SOME MODERN NOISES

Long before the beginning of modern science, men were making sounds that were disagreeable to their neighbors. Many of these were the natural noises

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[94] See in this regard Sherrill, "The Jet Noise is Getting Awful," New York Times Magazine, January 14, 1968, p. 24, in which the author quotes industry spokesmen to this effect.

[95] See, in this regard, *Scenic Hudson Preservation Conference* v. *F.P.C.*, 354 F. 2d 608 (2d Cir. 1965), *cert. denied*, 384 U.S. 941 (1966).

[96] *Udall* v. *F.P.C.*, 387 U.S. 428, 450 (1967).

[97] See in this regard *Washington/Baltimore Helicopter Service Investigation*, CAB Docket No. 17665 in which the Department of Transportation, a party of record considering a proposal to relieve Washington National Airport by increasing flights from neighboring Dulles and Friendship by providing helicopter service between airports, noted that while helicopters were in themselves noisy, they were considerably less noisy than the now existing jet aircraft that fly over the same area.

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I am indebted to Richard A. Lempert, Esq., of New York City for the collection of railway of people and their domestic animals but a surprisingly large number were the noises of industry. One of the adventures of Don Quixote and Sancho Panza begins with the "terrible din" of a fulling mill. The fourteenth century Sir Gawain and The Green Knight speaks of the "wondrous loud noise" of a grind stone. The streets of the medieval town resounded with the "beating out of iron upon a blacksmith's anvil, hammering of carpenters, pounding on sheet copper from a kettle maker's." A poem written about 1350 complains that blacksmiths "Drive me to death with the din of their dints"; because of them "No man . . . can get a night's rest." And four hundred years later in what we think of as the peaceful colonial city of Philadelphia, Ben Franklin felt compelled to move from High Street to Second and Sassafras because "the din of the Market increases upon me; and that, with frequent interruptions, has, I find, made me say some things twice over."[1]

These random selections illustrate that noise, far from being an invention of the modern world, has been a problem as long as men have been living together in towns. For this reason the law began to concern itself very early with the types of annoyance characteristic of communal living. These annoyances were not limited to noise, but encompassed the entire range of activities resulting from the use of one's own property in a way that may adversely affect the use of a neighbor's property—smoke, smells, soot, bright lights, vibration, flooding, water pollution and explosive blasts, as well as noise.[2]

The peculiar contribution of modern science has been to add some new types of noise-makers. While the source of the annoyance is different, the impact of these noises on neighbors is not new. Airplanes, trucks and outboard motor boats can drown out voices and interrupt sleep. The sonic boom of low flying supersonic aircraft can break windows. Experiments are currently being conducted with noises that kill small animals and would presumably kill humans. While the addition of any new noises to an already noisy world is upsetting, legal principles already exist, and have long existed, which deal with interferences that drown out voices or interrupt sleep, that break windows and that kill animals and humans. As has so often been the case in the history of the law, the story of noise and the law is not one of the developments of new principles to fit new noises, but the application of established principles to solve old problems arising in somewhat different forms.[3]

II. ABOUT SOME CHARACTERISTICS OF NOISE

For practical purposes the discussion of the law of noise can be considered in two parts: first, the rights of a complainant against a private person and second, the rights of a complainant against the government or an agency acting by government authority.

Whether the noise-maker is a private person or the government, it is important to recognize that noise is more difficult to deal with than many nuisances because at certain levels, at least, it is largely subjective.[4] Noise, by definition, is sound that is not wanted by those who hear it.[5] A Mozart divertimento when played

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and highway cases that appears in notes 110 and 111 and to A. C. L. Smith, Esq., of London, England, for assistance in compiling the information on English law contained in Part IV, *infra*.

[1] Cervantes, The Ingenious Gentleman Don Quixote de la Mancha ch. XX (Putnam ed. 1949); Medieval Romances 380 (Loomis ed. 1957); Hunt, Fifteenth Century England 26 (1962); Chaucer's World 16–17 (Rickert ed. 1962); Bridenbaugh, Cities in Revolt 24 (1964).

[2] "There is, I apprehend, no distinction between any of the cases, whether it be smoke, smell, noise, vapour, or water, or any other gas or fluid." Lord Romilly in Crump v. Lambert, L.R. 3 Eq. 409, 413 (1867).

[3] See Judge Friendly, Book Review, 77 Harv. L. Rev. 582, 583 (1964): "[I]n the main, 'air law' is simply the application of general legal principles and skills to a new industry made possible by technological advance—the equivalent for lawyers of our century of what the railroad, the telephone, and the telegraph demanded of our nineteenth century forebears."

[4] Certain noises, however, can do visible physical damage, the best known being the ability even at relatively low volumes to break glass—a characteristic that has been recognized for more than a thousand years. Scholes, The Oxford Companion to Music 6, 14 (8th ed. 1950).

[5] Handbook of Noise Control 1–11 (Harris ed. 1957). Sound is caused by the exertion of energy (a hand clap for example, or a bow pulled across the strings of a violin) transmitted by pressure waves from the source of the energy to the receiver. In some instances the pressure waves may be inaudible—they may be too weak or, because of their frequency, may be beyond the capacity of the human ear to receive. When audible, these pressure waves are "sound" and when the sound is unwanted by the receiver, it is "noise."

on my phonograph may be a noise to you as transmitted through our adjoining walls. Even if it were not distorted in the transmission, you might not like Mozart or you might not like it at the particular time I have chosen to play it. This would make it noise to you. Also, some sounds are more objectionable than others. People who work comfortably within the hum of an air conditioner might be most uncomfortable if they were subjected to a high frequency noise of the same intensity, say the scratch of a fingernail on a blackboard. Noises that have frightening connotations are more annoying than those with pleasant connotations.[6] And a high level of tolerance can be developed to noises that have become familiar; the city dweller temporarily in the country may find his sleep interrupted by barnyard noises while the rural resident often may experience difficulty sleeping in the city because of the unfamiliar sounds of urban activity. All of these have been factors which have shaped the law pertaining to this subject.

III. ABOUT NOISES MADE BY PRIVATE PERSONS[7]

For hundreds of years, indeed throughout most of the history of the common law as we know it, courts have been struggling to reconcile the conflicting interests of two property owners—one who believes that his ownership entitles him to use his property as he wills and the neighbor who believes that his ownership entitles him to enjoy his property without annoyance.[8] It is obvious that out of such conflict, in which both sides are relying on their "absolute" property rights, no easily applied set of rules could be established. Courts have attempted to do justice, case by case, but two major principles, it would appear from the *Restatement of the Law of Torts*, have evolved:

> First, each person must put up with a certain amount of annoyance, inconvenience and interference.[9]
>
> Second, in determining the amount of annoyance, inconvenience and interference that must be tolerated, the gravity of the harm to the complainant should be weighed against the utility of the conduct of his troublesome neighbor.[10]

The first of these principles tells us what every city dweller experiences every day of his life. It is not possible to live together without putting up with annoyances created by the activities of those living near us. In some areas, such as those devoted largely to industry, we must expect more annoyances than in others.

The second principle, the gravity-utility rule, is less easy to understand. This is because the word "utility" is used in the *Restatement* in a broad and, it seems to me, somewhat awkward sense. Another rule is required in the *Restatement* to make it plain that in determining the "utility" of the defendant's conduct one must consider, in addition to the social value of his conduct, its suitability to the locality and the "impracticability of preventing or avoiding" the annoyance.[11]

Even with this explanation, the gravity-utility rule is confusing to one who is not an expert in the field. A simpler introduction to the cases, although possibly not as complete an explanation, is that courts are primarily concerned, on the one hand, with the harm that is being caused to the plaintiff by the annoyance, and on the other hand, with the reasonableness of the defendant's conduct and the harm that would be caused to the defendant (and sometimes to the public) if the defendant were forced to discontinue the activity that produces the annoyance. When an injunction is sought, the opposing elements on the scale are weighed against each other.[12] When damages are sought and proved, the question is largely whether the defendant's conduct is reasonable.[13]

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[6] "[P]ublic tolerance . . . depends greatly on the hazards that people associate with a noise." Dr. Paul S. Veneklasen, acoustical consultant, in *Hearings on Aircraft Noise Problems Before the Subcommittees of the House Committee on Interstate and Foreign Commerce*, 86th & 87th Cong., 590 (1962).

[7] An asterisk following the names of a case in Parts III and IV indicates that noise has not been a factual element in the case, but the rationale has been thought applicable to the point for which it is cited.

[8] See generally CHAFEE, CASES *on* EQUITABLE RELIEF AGAINST TORTS 55 (1924); 2 POLLACK & MAITLAND, THE HISTORY OF THE ENGLISH LAW 53 (2d ed. 1911); 4 RESTATEMENT, TORTS 218–19 (1939).

[9] See 4 RESTATEMENT, TORTS § 822, comment on clause (d) (1939).

[10] See *id.*, § 826. See also 1 HARPER & JAMES, TORTS 73 (1956); PROSSER, TORTS § 88 (3d ed. 1964).

[11] See 4 RESTATEMENT, TORTS § 828 and comment on clause (c) (1939).

What circumstances, then, will justify the award of damages or the issuance of an injunction for noise made by a private person?

A. *The Award of Damages*

In the typical case, the plaintiff can recover damages when the defendant's noise causes a decrease in the value of plaintiff's property.[14] It is frequently said that damages can also be recovered for injury to plaintiff's person or to that of members of his household, but as a practical matter recovery for personal injury is rare and the amounts of recovery are usually small, possibly because of the extreme difficulty of proving injury from noise.[15]

No damages can be recovered for a noise that constitutes a mere annoyance.[16] All of us must accept the normal noises of communal living.[17] The standard is not determined by the individual idiosyncracies of the plaintiff, but by what a person of "ordinary sensibilities" can tolerate.[18] And one who purchases property or builds in an area devoted to noisy activity cannot recover damages for noise of the character that could be reasonably anticipated in the area.[19] No one can move into a quarter given over to foundries and boiler shops and demand the quiet of a farm." [20] One who buys into such an area takes his property subject to a sort of easement.[21]

B. *The Issuance of an Injunction* [22]

Courts are reluctant to grant an injunction when to do so would cripple a business that is being properly conducted.[23] For this reason, the alert plaintiff will commence his action before the facility which threatens to be a nuisance is constructed and before the defendant has irretrievably laid out a substantial expenditure.[24] If the plaintiff is unwilling to seek injunctive relief at this stage, he would nevertheless be well advised to warn the defendant in writing that the incipient nuisance will not be tolerated and to endeavor to get some advance assurances.[25]

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[12] "The relative hardship likely to result to the defendant if injunction is granted and to the plaintiff if it is denied, is one of the factors to be considered in determining the appropriateness of an injunction against tort." *Id.* § 941. See Harrisonville v. W. S. Dickey Clay Mfg. Co.,* 289 U.S. 334, 338 (1933). *But cf.* Vowinckel v. N. Clark & Sons,* 216 Cal. 156, 13 P.2d 733 (1932).

[13] In determining whether noise is a nuisance "the character, volume, time, place and duration of its occurrence, as well as the locality, must be taken into consideration." Lloyd, *Noise as a Nuisance,* 82 U. Pa. L. Rev. 567, 569 (1934). This article contains an interesting collection of cases dealing with specific types of noises such as bells, barking dogs, music, etc.

[14] See, *e.g.*, Maitland v. Twin City Aviation Corp., 254 Wis. 541, 37 N.W.2d 74 (1949) (low flights from private airport).

[15] "The action for private nuisance . . . is properly an action for the invasion of a person's interest in . . . land," but sometimes recovery for personal injury is allowed in an action for private nuisance. 4 Restatement, Torts 219–20 (1939), and § 827, comment on clause (b). One of the rare cases in which more than nominal damages have been recovered for personal discomfort due to noise is Dixon v. New York Trap Rock Co., 293 N.Y. 509, 58 N.E.2d 517 (1944), involving the continuous blasting at a quarry where there was a recovery of $2,000 for drugs, medical bills and demonstrable decline in health, in addition to recovery for damage to property. In Walker v. Wearb, 6 N.Y.S.2d 548 (Sup. Ct. 1938), the award was $12 for medicine and 6¢ for nominal damages. *But see, Developments in the Law—Injunctions,* 78 Harv. L. Rev. 994, 1003 (1965). "many courts . . . have awarded substantial sums for . . . the personal discomforts caused by noise . . .," citing no cases.

[16] Liability in damages for nuisance "begins only when the interference causes substantial harm." Prosser, *op. cit. supra* note 10, § 88.

[17] 4 Restatment, Torts § 822, comment on clause (d) (1939).

[18] See, *e.g.*, Gunther v. E. I. duPont de Nemours & Co., 157 F. Supp. 25, 32 (N.D. W.Va. 1957), *appeal dismissed*, 255 F.2d 710 (4th Cir. 1958).

[19] "If my neighbor makes a tan-yard, so as to annoy and render less salubrious the air of my house or garden, the law will furnish me with a remedy; but if he is first in possession of the air, and I fix my habitation near him, the nuisance is of my own seeking, and may continue." 2 Blackstone, Commentaries *402. "He who dislikes the noise of traffic must not set up his abode in the heart of a great city." Salmond, Torts 182 (12th ed. 1957). *But see* Campbell v. Seaman,* 63 N.Y. 568, 584 (1876) (noxious gases); Laflin-Rand Powder Co. v. Tearney, 131 Ill. 322, 23 N.E. 389 (1890) (exploding powder magazine).

[20] Stevens v. Rockport Granite Co., 216 Mass. 486, 488, 104 N.E. 371, 373 (1914). See also Irby v. Panama Ice Co., 184 La. 1082, 168 So. 306 (1936); Grzelka v. Chevrolet Motor Car Co., 286 Mich. 141, 281 N.W. 568 (1938); Eller v. Koehler, 68 Ohio St. 51, 67 N.E. 89 (1903).

[21] 1 Harper & James, Torts 74 (1956).

[22] At one time it was necessary for the plaintiff to establish his right at law before he could obtain an injunction against a nuisance. See Ames, Cases in Equity Jurisdiction 553–60 (1904); Lewis, *Injunctions Against Nuisances and the Rule Requiring the Plaintiff To Establish His Right at Law,* 56 U. Pa. L. Rev. 289 (1908). A useful general discussion on injunctive relief against noise appears in Note, 25 Va. L. Rev. 465 (1939).

A California statute denies the right to an injunction for private nuisances created by certain business activities in areas zoned for those activities. Cal. Civ. Prog. Code § 731a.

[23] See, *e.g.*, De Blois v. Bowers,* 44 F.2d 621, 623–24 (D. Mass. 1930); McCarthy v. Bunker Hill & Sullivan Mining & Concentrating Co., 164 Fed. 927, 940 (9th Cir. 1908); Pawlowicz v. American Locomotive Co., 90 Misc. 450, 154 N.Y.S. 768 (Sup. Ct. 1915).

Once a business is under way, a noise that causes a substantial decrease in the value of the plaintiff's property or a material discomfort to plaintiff will be enjoined:

(a) if the annoyance is due to poor design or improper operation of defendant's facility and can be abated by the adoption of an improved design or operation,[26] but the improvement must be one that is commercially feasible,[27] or

(b) if the activity creating the noise was established in a neighborhood obviously inappropriate for the activity.[28]

A plaintiff who establishes his right to an injunction may, in the same suit, also recover compensation for damages to the effective date of the decree.[29]

It is often said that an injunction will not issue if there is no evidence of a material decline in the value of a plaintiff's property or a material injury to his person.[30] But as a practical matter, a noise of a type that would be annoying to the average person may be enjoined, even though damages are not recoverable if the activity causing the noise falls within either of the two categories listed above or if the noise can be abated at little cost to the defendant.[31] However, when that is not the case and the defendant's activity is neither negligently designed or operated nor conducted in an inappropriate place, an injunction will rarely issue without a showing of material property damage.[32] And when the defendant has engaged in a naturally noisy activity over a long period of time and there is no showing of negligence, his neighbors may be required to tolerate a very substantial amount of annoyance.[33]

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[24] "If the plaintiff had filed his bill before the mill was built. the balance of convenience would have been different, and we should not have hesitated to stop what as yet remained only a project." Judge L. Hand in Smith v. Staso Milling Co., 18 F.2d 736, 738 (2d Cir. 1927). See Cities Serv. Oil Co. v. Roberts, 62 F.2d 579 (10th Cir. 1933); Herbert v. Rainey, 54 Fed. 248 (W.D. Pa. 1892). See also New York v. Pine,* 185 U.S. 93, 99 (1902). *But cf.* Commerce Oil Ref. Corp. v. Miner,* 281 F.2d 465 (1st Cir.), *cert. denied*, 364 U.S. 910 (1960) (refusal to enjoin anticipatory nuisance).

[25] In Swetland v. Curtiss Airports Corp., 55 F.2d 201, 204 (6th Cir. 1932), where the plaintiffs had given prior notice that the intended use of the land "would destroy their property for residential purposes," the court rejected cases cited by defendant against the issuance of an injunction because "in many of them there was not a precedent or concurrent notice." See also Smith v. Staso Milling Co., *supra* note 24, at 738; Krocker v. Westmoreland Planing Mill Co.. 274 Pa. 143, 145, 117 Atl. 669 (1922).

[26] Courts will usually require the defendant to do whatever is reasonably necessary to minimize the annoyance, including modifications to bring the defendant's plant or mode of operations up to the latest developments for the control of the annoyance complained of. Dauberman v. Grant, 198 Cal. 586, 246 Pac. 319 (1926). Private flights required to fly at higher altitudes: Anderson v. Souza, 38 Cal. 2d 825, 243 P.2d 497 (1952); Vanderslice v. Shawn, 26 Del. Ch. 225, 27 A.2d 87 (1942); Scott v. Dudley, 214 Ga. 565, 105 S.E.2d 752 (1958); Hyde v. Somerset Air Service, Inc., 1 N.J. Super 346, 61 A.2d 645 (1948); Barrier v. Troutman, 231 N.C. 47, 55 S.E.2d 923 (1949); Reynolds v. Wilson, 2 Av. Cas. 14863 (Pa. C.P. 1949); Maitland v. Twin City Aviation Corp., 254 Wis. 541, 37 N.W.2d 74 (1949).

[27] See. *e.g.,* Grzelka v. Chevrolet Motor Car Co., 286 Mich. 141, 281 N.W. 568 (1938).

[28] Residential area cases: Swetland v. Curtiss Airports Corp., 55 F.2d 201 (6th Cir. 1932); Brandes v. Mitterling, 67 Ariz. 349, 196 P.2d 464 (1948); People v. Dycer Flying Serv. Inc.. 1 Av. Cas. 817 (Cal. Super Ct. 1939); Kramer v. Sweet, 179 Ore. 324, 169 P.2d 892 (1946) (slaughterhouse); Krocker v. Westmoreland Planing Mill Co., 274 Pa. 143, 117 Atl. 669 (1922) (planing mill); Gay v. Taylor, 19 Pa. D. & C. 31 (C.P. 1932) (private airport); Johnson v. Drysdale, 66 S.D. 436, 285 N.W. 301 (1939) (horses).

[29] See, *e.g.*, Anderson v. Souza, 38 Cal. 2d 825, 243 P.2d 497 (1952).

[30] "An injunction will not be granted unless there is either an actionable invasion under the rule stated in this Section [dealing with liability for damages] or unless an invasion is threatened which would be actionable hereunder." 4 RESTATEMENT, TORTS, § 822, general comment *b* (1939).

[31] "If there be no such remedy at law, then, *a fortiori,* a court of equity ought to give its aid to vindicate and perpetuate the right of the plaintiffs." Story, J., in Webb v. Portland Mfg. Co.,* 29 Fed. Cas. 506 (No. 17322) (1838) (diversion of water). The barking dog cases are typical instances of abatement without a showing of compensable damage to the plaintiff. See, *e.g.*, Adams v. Hamilton Carhartt Overall Co., 293 Ky. 443, 169 S.W.2d 294 (1943), and cases cited.

[32] Injunction against flights operating from private air field denied where no substantial property damage shown: Smith v. New England Aircraft Co., 270 Mass. 511, 170 N.E. 385 (1930); Kuntz v. Werner Flying Serv., Inc., 257 Wis. 405, 43 N.W.2d 476 (1950). Other examples in which injunction denied on failure to show substantial property damage: Gunther v. E. I. duPont de Nemours & Co., 157 F. Supp. 25 (N.D. W.Va. 1957), *appeal dismissed on procedural grounds,* 255 F.2d 710 (4th Cir. 1958) (blasting); Bostick v. Smoot Sand & Gravel Corp., 154 F. Supp. 744 (D. Md. 1957), *aff'd on issue of nuisance,* 260 F.2d 534, 541 (4th Cir. 1958) (dredging).

[33] See, *e.g.*, Benton v. Kernan, 130 N.J. Eq. 193, 21 A.2d 755 (1941); Pawlowicz v. American Locomotive Co., 90 Misc. 450, 154 N.Y.S. 768 (Sup. Ct. 1915).

Contrasting sharply with these situations requiring negligent design and operation, or inappropriate location, or material damage before an injunction can be obtained, there are numerous circumstances in which a relatively minor showing of annoyance will be deemed sufficient for the granting of relief. For example, if the defendant deliberately made the noise for the purpose of annoying his neighbor, the plaintiff can enjoin the continuance of the noise noisy activities during the usual hours of bedtime,[38] but the only limit to the possibilities of designing appropriate relief is the imagination of the court and of the parties applied to the peculiar circumstances in each case.[39]

IV. ABOUT NOISES MADE BY GOVERNMENT OR BY GOVERNMENT-AUTHORIZED ENTITIES

Many of the most troublesome modern noises are caused by the government or government-authorized entities involved in the operation of railroads, highways, and aircraft. The right to recover in such cases is affected by two principles that apply to the performance of governmental functions.

There is, first of all, the well-recognized concept of sovereign immunity—that the government is not liable for any of its acts except those for which recovery has been expressly provided. Almost inextricably intertwined with that concept is the second principle that members of the public shall bear without redress certain of the burdens that arise from action which the government has taken or has authorized in the common interest. Wholly apart from the arbitrary bar of sovereign immunity, there is the very practical consideration that "Government hardly could go on if to some extent values incident to property could not be diminished without paying for every such change in the general law. As long recognized, some values are enjoyed under an implied limitation and must yield to the police power." [40] A man drafted into the military forces may suffer a substantial loss of earnings for which he is not compensated. The operator of a formerly prosperous gasoline station may find his business has disappeared after the opening of a new highway. An employer may be put out of business by being required to raise his wages to a minimum level. It is inevitable in our form of political system, and perhaps in any form of political system, that the government, acting in the public interest, will perform functions or authorize the performance of functions that will be harmful to some people and not to others or that will be more harmful to some than to others. This occurs every day, and in most cases no compensation is paid to those harmed.

The application of these principles to the problem of noise is illustrated by the decision of the United States Supreme Court in *Richards* v. *Washington Terminal.*[41] In that case, the plaintiff, whose house was approximately one hundred feet from defendant's railroad track and tunnel, brought an action to recover for damage to his property resulting from an alleged nuisance. Plaintiff suffered (1) from the noise, vibration, and smoke of the passing trains "cracking the walls . . . breaking glass in the windows, and disturbing the peace and slumber of the occupants" and (2) from gas and smoke forced out of the tunnel and directed onto plaintiff's property by a fanning system. Defendant's activities, however, had been authorized by the government—its tracks and tunnel were located, constructed, and maintained under acts of Congress. There was no claim that the trains were negligently constructed, operated, or maintained.

The Court held that the plaintiff, like all other property owners along a railroad right-of-way, was required to bear without redress the amount of noise, vibration, and smoke incident to the running of the trains.[42] However, the plaintiff was entitled to compensation to the extent he was damaged by the fan arrangement which artificially concentrated gas and smoke on the plaintiff to a degree not shared by other property owners, "and this, without, so far as appears, any real necessity existing for such damage."[43]

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[38] See, *e.g.*, Kosich v. Poultrymen's Serv. Corp., 136 N.J. Eq. 571, 43 A.2d 15 (1945) (poultry feed plant); City of Rochester v. Charlotte Docks Co., 114 N.Y.S.2d 37 (Sup. Ct. 1952) (emptying conveyor cars); Firth v. Scherzberg, 366 Pa. 443, 77 A.2d 443 (1951) (private truck terminal); Rhoads v. Piacitelli, 2 Av. Cas. 14658 (Pa. C.P. 1948) (private airport). See also cases cited in note 36 *supra*.

[39] See, *e.g.*, Five Oaks Corp. v. Gathmann, 190 Md. 348, 58 A.2d 656 (1948). "The best solution is often to be found in what may be called an experimental injunction, a definite order subject to revision in the light of experience therewith." 4 RESTATEMENT, TORTS § 943, at p. 725, comment (1939). See also *Developments in the Law—Injunctions,* 78 HARV. L. REV. 994, 1063–64 (1965).

[40] Mr. Justice Holmes in Pennsylvania Coal Co. v. Mahon, 260 U.S. 393, 413 (1922).

[41] 233 U.S. 546 (1914).

[42] *Id.* at 553–54 (1914): "[R]ailroads constructed and operated for the public use, although with private capital and for private gain, are not subject to actions in behalf of of neighboring property owners for the ordinary damages attributable to the operation of the railroad, in the absence of negligence," including such damages as result from "the noises and vibrations incident to the running of trains, the necessary emission of smoke and sparks from the locomotives, and similar annoyances inseparable from the normal and non-negligent operation of a railroad."

The general conclusion to be drawn from *Richards* v. *Washington Terminal* is that under federal law no right of action exists in private property owners for noise made by an entity functioning under authority of the government (and, a fortiori, for noise made by the government itself) even though the noise may cause a decline in the value of affected property.[44] In such circumstances both damages and equitable relief are denied.

However, it is necessary to qualify this broad rule somewhat by two limitations: First, the activity being performed by the government or government-authorized entity must be sanctioned by law.[45] Second, the facility creating the noise must be properly designed and operated,[46] and in certain limited cases a government-authorized entity will be held responsible when it has not properly located the facility.[47]

The legal consequences of exceeding these limitations are not always the same for the government as for a public utility. The government begins with complete immunity, and claims against it can be enforced only to the extent that this immunity has been specifically waived.[48] The situation of the public utility is just the reverse. Claims against utilities can be enforced except to the extent they are performing acts specifically authorized by the government; their immunity is strictly limited to that which has been derived from the government, and their acts are protected only so long as they are a necessary consequence of the exercise of the authority granted by the government.[49] Objectionable actions which fall within such authority are sometimes referred to as "legalized nuisances."[50] Any action outside such authority subjects the utility to liability in the same manner as any private citizen.[51] Thus, the railroad in *Richards* v. *Washington Terminal* was responsible for the smoke concentrated on the plaintiff because the conduct of the railroad in this respect was not a necessary consequence of the authority granted to it by the government.[52]

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[43] *Id.* at 556–57.

[44] Railroad: Richards v. Washington Terminal Co., 233 U.S. 546 (1914). Military aircraft: Batten v. United States, 306 F.2d 580 (10th Cir. 1962), *cert. denied,* 371 U.S. 955, *rehearing denied,* 372 U.S. 925 (1963); Moore v. United States, 185 F. Supp. 399 (N.D. Tex. 1960); Freeman v. United States, 167 F. Supp. 541 (W.D. Okla. 1958); Fitch v. United States, 5 Av. Cas. 17841 (D. Kan. 1958); Boskovich v. United States, 3 Av. Cas. 17252 (D. Utah 1950); Avery v. United States, 330 F.2d 640 (Ct. Cl. 1964); Aaron v. United States, 311 F.2d 798 (Ct. Cl. 1963); Watson v. United States, 171 F. Supp. 283 (Ct. Cl. 1959). Military aircraft on warm-up pads: Mock v. United States, 8 Av. Cas. 18080 (Ct. Cl. 1964). Military bombing and ground detonation: Nunnally v. United States, 239 F.2d 521 (4th Cir., 1956). Engine test cell: Bellamy v. United States, 235 F. Supp. 139 (E.D. S.C. 1964); Pope v. United States, 173 F. Supp. 36 (N.D. Tex. 1959). *But cf.* Martin v. Port of Seattle, 64 Wash. 2d 324, 391 P.2d 540 (1964), *cert. denied,* 379 U.S. 989 (1905); Thornburg v. Port of Portland, 233 Ore. 178, 376 P.2d 100 (1962).

[45] See Transportation Co. v. Chicago,* 99 U.S. 635, 640 (1879): "If the statute be such as the legislature has power to pass, the acts are lawful, and are not nuisances, unless the power has been exceeded."

[46] *E.g.,* Transcontinental Gas Pipe Line Co. v. Gault, 198 F.2d 196 (4th Cir. 1952); Alford v. Illinois Central R. Co.,* 86 F. Supp. 424(W.D. La. 1949), *aff'd* 187 F.2d 144 (5th Cir. 1951), *cert. denied,* 342 U.S. 825 (1951) (smoke). See Chronister v. City of Atlanta, 99 Ga. App. 447, 108 S.E.2d 731 (1959); Brooks v. Patterson, 159 Fla. 263, 31 So. 2d 472 (1947); Delta Air Corp. v. Kersey, 193 Ga. 862, 20 S.E.2d 245 (1942); Thrasher v. City of Atlanta, 178 Ga. 514, 173 S.E. 817 (1934); Jeffers v. Montana Power Co.,* 68 Mont. 114 217 Pac. 652 (1923). The cases enjoining a nuisance from the discharge of city sewage (see, *e.g.,* note in 77 L. Ed. 1213) are illustrative since it is obvious that sewers can be designed which will not cause nuisances.

[47] In deference to the executive and legislative branches, courts will not ordinarily contest the location of a government facility. "[T]he law does not permit courts to select the location of sites for the establishment of essential public enterprises." State *ex rel.* Helsel v. Board of County Comm'rs, 37 Ohio Op. 58, 79 N.E.2d 698, 709, *appeal dismissed,* 149 Ohio St. 583, 79 N.E.2d. 911 (1948). See also United States v. 64.88 Acres of Land,* 244 F.2d 534 (3d Cir. 1957). *But cf.* Hassell v. City & County of San Francisco,* 11 Cal. 2d 168, 78 P.2d 1021 (1938).

In the case of a public utility, the reasonableness of the location can be questioned when feasible alternatives exist, as for example, when the question is the location of railroad shops and switchyards as distinguished from the tracks themselves. Baltimore & P. R.R. v. Fifth Baptist Church, 108 U.S. 317, 330–32 (1883). *But cf.* Thompson v. Kimball, 165 F.2d 677 (8th Cir. 1948), denying recovery for noise of switching engines spotted so that plaintiff "gets its worst," since that is merely a matter of degree in a situation where the injury is "common to the public whose property is situated . . . near the switch-yard."

Throughout this article, the phrase "public utility" is used in its broader sense—an entity deriving its authority to operate from the government.

[48] In the case of the federal government, liability can be enforced only when a "taking" occurs under the fifth amendment for which an action can be brought under the Tucker Act, 62 Stat. 940 (1948), as amended, 28 U.S.C. § 1491 (1958) or when a government employee has committed a tort of the type for which recovery has been provided, since 1946, by the Federal Tort Claims Act, 6, Stat. 982 (1948), 28 U.S.C. § 2671 (1958) et seq. Under the Federal Tort Claims Act, recovery is not permitted for acts of an employee "exercising due care in the execution of a statute or regulation" or claims "based upon the exercise [of] . . . a discretionary function or duty on the part of a federal agency . . ." Ordenarily, no recovery is permitted for the deliberate act of government in performing its functions. Thus, for example, while the act permits no recovery for damages resulting from government construction or operation of an airport next to a residence, it would permit recovery for damages resulting from the negligent or wrongful act of a military pilot oper-

Claims which have arisen from the sonic boom of supersonic aircraft operated by the government fall within the second of the two limitations on the broad rule of no liability. A normal, properly conducted flight is one that accelerates to supersonic speed at altitudes high enough to avoid the overpressures that cause physical damage.[53] Since physical damage is not a necessary consequence of operating supersonic aircraft, persons suffering such damage are entitled to recover.[54] However, no recovery will be allowed for the mere annoyance caused

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ating from the airport. United States v. Gaidys,* 194 F.2d 762 (10th Cir. 1952). See also Dalehite v. United States,* 346 U.S. 15, 44–45 (1953), and discussion of Federal Tort Claims Act in 2 HARPER & JAMES, TORTS 1648–67 (1956).

[49] "The immunity is limited to such damages as naturally and unavoidably result from the proper conduct of the road and are shared generally by property owners whose lands lie within range of the inconveniences necessarily incident to proximity to a railroad." Richards v. Washington Terminal Co., 233 U.S. 546, 554 (1914).

[50] "That cannot be a nuisance, such as to give a common-law right of action, which the law authorizes." Transportation Co. v. Chicago,* 99 U.S. 635, 640 (1879). See also Richards v. Washington Terminal Co., 233 U.S. 546, 551, 554 (1914), and compare United States v. Causby, 328 U.S. 256, 262 (1946). And see Note, *Nuisance and Legislative Authorization,* 52 COLUM. L. REV. 781 (1952).

Legislation in several states provides that "Nothing which is done or maintained under the express authority of a statute can be deemed a nuisance." See, *e.g.,* CAL. CIV. CODE § 3482 (1960); IDAHO CODE ANN. § 52–108 (1957); MONT. REV. CODES ANN. § 57–104 (1962); N.D. CENT. CODE 42–01–12 (1960); OKLA. STAT. tit. 50 § 4 (1962); S.D. CODE § 37.4703 (1939); WASH. REV. CODE § 7.48.160 (1952).

[51] "When an act is done by a [railway] company in excess of its powers, or in a wanton and careless use of them, there is an injury for which the sufferer retains a remedy by an action at common law, or by suit in equity for an injunction; but things done by a company in the due execution of its powers are lawful, being duly authorized, and no action lies on account of them." Lord Westbury, dissenting on other grounds, in Ricket v. Metropolitan Ry.,* L.R. 2 H.L. 175, 202 (1867).

[52] The court states that, if the damage could not be prevented, the railroad should proceed to acquire plaintiff's property by purchase or condemnation, but, if the damage is "readily preventable, the statute furnishes no excuse and defendant's responsibility follows on general principles" (*i.e.,* to the extent its action is outside the statute, the railroad has no immunity and must pay for the nuisance). Richards v. Washington Terminal Co., 233 U.S. 546, 557 (1914). See also Baltimore & P.R.R. v. Fifth Baptist Church, 108 U.S. 317, 331 (1883), which points out that the authority conferred on the railroad was accompanied by an "implied qualification" governing where it could place its works.

[53] The design criteria of the supersonic transport aircraft currently under consideration by the United States government provide that the "maximum over-pressure" (*i.e.*, the pressures created by the shock waves in excess of normal pressures at sea level) shall not exceed two pounds per square foot. "Request for Proposals for the Development of a Commercial Supersonic Transport," Federal Aviation Agency, August 15, 1963, p. 19. Experiments of the Federal Aviation Agency have demonstrated that over-pressures of two pounds per square foot or less will not break normal window glass. Power, *Some Results of the Oklahoma City Sonic Boom Tests,* 4 MATERIALS RESEARCH & STANDARDS 623 (1964). See Roth, *Sonic Boom,* 44 A.B.A.J. 216, 220 (1958), for Air Force standard operating procedures.

[54] "According to the face of the amended complaint, the United States committed a wrong for which it was liable under the Tort Claims Act . . ." Lloyds' London v. Blair, 262 F.2d 211 (10th Cir. 1958). See also Coxsey v. Halaby, 334 F.2d 286 (10th Cir. 1964), and 231 F. Supp. 978 (D.C. Okla. 1964). *But see* Huslander v. United States, 234 F. Supp. 1004 (W.D. N.Y. 1964), in which the court granted the government's motion for summary judgment on the theory that undertaking supersonic flight was a "discretionary function" under the Federal Tort Claims Act, 28 U.S.C. § 1491 (1958). This conclusion seems to be based on a misunderstanding of *Dalehite*, in which the Supreme Court denied recovery for damage due to the explosion of government-made fertilizer which "experience showed could be handled safely in the manner it was handled here" and cited *McPherson v. Buick* to indicate that recovery *would* be allowed when damage is foreseeable as the "probable" result of a government activity. Dalehite v. United States, 346 U.S. 15, 42 (1953). Thus, in the *Huslander* case, if the flight had been specifically authorized by the Air Force, those granting the authorization knew it would break windows. But the court in *Huslander* even denied plaintiffs the opportunity to "ascertain whether established policies and procedures [of the Air Force] were adhered to in this case." 234 F. Supp. 1004, 1007 (W.D. N.Y. 1964).

An extended discussion of federal liability for sonic booms appears in Comment, 31 SO. CAL. L. REV. 259 (1958).

by sonic booms, even though the annoyance may be severe enough to occasion a decline in property values. This is a burden shared by society in general—a part of the burden of communal living.

The reasons leading to these results are to be found in an analysis of our constitutional structure.

A. The Federal Constitution

Since there is hardly a government act which could not cause someone substantial damage, an arbitrary boundary line must be drawn between compensable and noncompensable injury. In the case of the federal government that boundary was embodied in the fifth amendment which provides that property may not be taken for public use without just compensation.

"The Fifth Amendment . . . undertakes to redistribute certain economic losses inflicted by public improvements so that they fall upon the public rather than wholly upon those who happen to lie in the path of the project. It does not undertake, however, to socialize all losses, but only those which result from a taking of property. If damages from any other cause are to be absorbed by the public, they must be assumed by act of Congress and may not be awarded by the courts merely by implication from the constitutional provision."[55]

The words "taking or "taken" have become so tainted with secondary meanings that it is easy to overlook the fact that when Smith has 'taken" my horse, it ordinarily means that Smith now has in his possession a horse that was formerly in my possession.[56] It does not mean that Smith has injured my horse.[57] This commonsense interpretation is close to the original constitutional sense, and even twentieth century cases speak of "taking" as the type of intentional act which would create an implied contract to pay.[58]

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[55] United States v. Willow River Power Co.,* 324 U.S. 499, 502 (1945). See also Legal Tender Cases,* 79 U.S. (12 Wall.) 457, 551 (1871). *But cf.* the dissenting opinion of Chief Judge Murrah in Batten v. United States, 306 F.2d 580, 587 (10th Cir. 1962), *cert. denied,* 371 U.S. 955, *rehearing denied,* 372 U.S. 925 (1963): "fairness and justice, as between the State and the citizen, requires the burden imposed to be borne by the public and not by the individual alone," cited with approval in Martin v. Port of Seattle, 64 Wash. 2d 324, 391 P.2d 540 (1964), *cert. denied,* 379 U.S. 989 (1965).

[56] "TAKE, to lay hold of, seize, grasp, get." SKEAT, ETYMOLOGICAL DICTIONARY OF THE ENGLISH LANGUAGE (rev. ed. 1956). And this is the meaning of the word as it is used in the distinguished ancestors of the constitution, Magna Carta §§ 28, 30 and 31 and Act Abolishing Relics of Feudalism and Fixing an Excise, 12 Charles 2, c. 24. § 12. So also in Treaty of Amity and Commerce with France, February 6, 1778, Art. xx, a contemporary of the Constitution, which deals separately with goods "taken" from merchants of the two countries and "injury" done them. This use of "taken" as an act of expropriation has been carried forward into a number of our modern treaties which provide that property of nationals "shall not be taken . . . except for a public purpose, nor shall it be taken without the prompt payment of just compensation." See, *e.g.,* Treaty of Friendship and Commerce with Pakistan, Art. VI § 4, 12 U.S.T. 111, 113 (1961). The identical language has even been used in a recent agreement between Cuba and Japan. Jennings, *The Sabbatino Controversy,* 20 Record of N.Y.C.B.A. 81, 88 (1965). In sum, the internationally accepted interpretation of "take" is exactly its original meaning—to "seize." After seven hundred years of consistent usage, it is difficult to see how this word can be tortured into a meaning broad enough to encompass damage occasioned by objectionable noise.

But see Sax, *Takings and the Police Power,* 74 YALE L.J. 36, 54–55 (1964): "The direct antecedents of the just compensation provision of the fifth amendment are the jurisprudential writings of such 17th and early 18th century scholars as Grotius, Pufendorf, Bynkershoek, Burlamaqui, and Vattel," who were "essentially non-property oriented."

[57] Constitutional protection exists only when property is taken for a "public *use.*" Although the latter word is frequently slighted, it confirms the concept of a purposeful appropriation of something that is wanted, in marked contrast to government action that incidentally happens to cause damage. *Cf.* United States v. General Motors Corp.,* 323 U.S. 373, 378 (1945): "In its primary meaning, the term 'taken' would seem to signify something more than destruction, for it might well be claimed that one does not take what he destroys. But the construction of the phrase has not been so narrow. The courts have held that the deprivation of the former owner rather than the accretion of a right or interest to the sovereign constitutes the aking." This explanaion is correct so far as it goes, but it fails to state the whole rule, which is that "the deprivation of the former owner" must be due to an action of the government which demonstrates its intention to appropriate. See notes 66 & 72 *infra.*

[58] See, *e.g.,* Bothwell v. United States,* 254 U.S. 231 (1920). "There was no actual taking of these things by the United States, and consequently no basis for an implied promise to make compensation." *Id.* at 233. See also *Developments in the Law—Remedies Against the United States and Its Officials,* 70 HARV. L. REV. 827, 876–82 (1957).

Despite loose language in some Supreme Court opinions,[59] the actual holdings of the Court dealing with rights in tangible property stick surprisingly close to the original concept, in which a taking involves the displacement of the owner from some part of his property by the government with the result that the government occupies what the landowner once occupied or had the right to occupy.[60] The rule seems to be that there can be no "taking" of tangible property under the federal constitution unless two conditions exist: First, there must be a physical or direct "invasion" of the property and, second, the invasion must be of a type which results in "exclusive" appropriation.[61] To have a taking the governmental use must be of a nature that excludes simultaneous use of the same property interest by the title holder. Or phrased differently, the government must effectively displace the owner from some part of his property.[62]

Consistent with this definition, the Court found that the noise and vibration did not constitute a "taking" in *Richards v. Washington Terminal*, despite the admitted damage to the neighboring properties.[63] And one strongly suspects that noise alone, no matter how aggravating (short of the lethal intensities with which our military forces have been experimenting, or something nearly as drastic) cannot constitute a taking as defined by the cases; *i.e.*, a displacement of the landowner by a direct or physical invasion of the government.[64] If "physical invasion" alone were the test, noise might constitute such an invasion—as Piggott pointed out as early as 1885.[65] However, by the second requirement of "exclusive" appropriation, the Supreme Court made it plain that sounds drifting through the air are not the type of invasion contemplated.

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[59] For example: (1) "[T]here are numerous authorities to sustain the doctrine that a serious interruption to the common and necessary use of property may be . . . equivalent to the taking of it, and that under the constitutional provisions it is not necessary that the land should be absolutely taken." Pumpelly v. Green Bay Co.,* 80 U.S. 166, 179 (1872), in which the court held that a flooding of plaintiff's land by a dam erected by the government was a taking. (2) "[A] destruction for public purposes may as well be a taking as would be an appropriation for the same end." United States v. Welch,* 217 U.S. 333, 339 (1910) (land flooded and private right-of-way cut off). (3) "Governmental action short of acquisition of title or occupancy has been held, if its effects are so complete as to deprive the owner of all or most of his interst in the subject matter, to amount to a taking," and "it matters not whether they were taken over by the Government or destroyed, since, as has been said, destruction is tantamount to taking." United States v. General Motors Corp.,* 323 U.S. 373 at 383 and 384 (1945), in which the Court held that when the Government took a temporary term from a leaseholder it must also pay the cost of the leaseholder's removal from the premises.

[60] The following Supreme Court cases have been frequently cited, along with United States v. Causby, 328 U.S. 256 (1946), and United States v. General Motors Corp., *supra* note 59, as extreme examples of taking: Armstrong v. United States,* 364 U.S. 40 (1960) (taking occurred when government exercised its contractual right to have a defaulting contractor transfer work-in-process to government, thereby depriving plaintiff of the ability to enforce his materialman's lien on the work); United States v. Kansas City Life Ins. Co.,* 339 U.S. 799 (1950) (a taking occurred when government raised river level to improve navigation, thereby "underflowing" plaintiff's property and rendering it unfit for farming); United States v. Dickinson,* 331 U.S. 745 (1947) (when government, to improve navigation, took plaintiff's property for flooding, it must also pay for resulting erosion and easement on remaining properties which would be intermittently flooded); Portsmouth Harbor Land & Hotel v. United States,* 260 U.S. 327 (1922) (establishment of a land battery permanently aimed over plaintiff's property and a fire control station on such property may be a taking if it shows an "abiding purpose to fire when the United States sees fit"); Pennsylvania Coal v. Mahon,* 260 U.S. 393, 414–15 (1922) (state statute prohibiting mining of coal by subsurface owners, except by complying with "commercially impracticable" requirements for support of the surface, would constitute taking: "while property may be regulated to a certain extent, if regulation goes too far it will be recognized as a taking"); United States v. Welch,* 217 U.S. 333 (1910) (when government took land for flooding, it must also pay for right-of-way rendered useless as a result of flooding).

[61] "[T]here was a physical invasion of the real estate of the private owner, and a practical ouster of his possession." Gibson v. United States,* 166 U.S. 269, 276 (1897). A "direct invasion" is used in United States v. Cress,* 243 U.S. 316, 327, 328 (1917) and in United States v. Causby, 328 U.S. 256, 265 (1946). The phrase "physical invasion" and "directly encroaching" appears in Transportation Co. v. Chicago,* 99 U.S. 635, 642 (1879).

"[T]here is no exclusive and permanent appropriation of any portion of plaintiff's land [and] since he is not wholly excluded from the use and enjoyment of his property, there has been no 'taking' of the land in the ordinary sense." Richards v. Washington Terminal Co., 233 U.S. 546, 551–52 (1914). In *Causby*, the Court said that "an accurate description of the property taken is essential, since that interest vests in the United States." United States v. Causby, *supra*, at 267. The term "practical ouster of his possession" is used in Transportation Co. v. Chicago,* *supra*, at 642, as well as in Gibson v. United States,* *supra*. In Sanguinetti v. United States,* 264 U.S. 146, 149 (1924), the Court said it was necessary that there be "an actual, permanent invasion of the land, amounting to an appropriation of and not merely an injury to the property."

[62] "[I]t is the character of the invasion, not the amount of damage resulting from it, so long as the damage is substantial, that determines the question whether it is a taking." United States v. Cress,* 243 U.S. 316, 328 (1917). Compare 2 Harper & James, Torts 1616 (1956): "It is enough that defendant's conduct destroys or substantially impairs the use of plaintiff's property either permanently or for a protracted period. . . . Consequential damage, however . . . are (*sic*) not included." See also Harvey, *Landowners' Rights in the Air Age—The Airport Dilemma*, 56 Mich. L. Rev. 1313, 1321 (1958), in which it is suggested that a taking occurs when the infringement is "sufficiently serious."

In considering these constitutional standards, it should be noted that the scope of this article is confined to "taking" as it applies to overt acts which affect physical property. The invasion concept is obviously inapplicable either to legislative acts of the government affecting physical property or to any acts of the government affecting interests in intangible property, which are also entitled to constitutional protection.[66] Some of those writing on this subject have attempted to throw all types of cases together higgledy-piggledy and to come out with a generalization which appears to cover them all, such as the statement that "any substantial interference which destroys or lessens the value of private property or the rights or enjoyment incidental to such property is, in fact and in law, a 'taking' in the constitutional sense, even though title and possession of the owner remain undisturbed." [67] If this bald generalization were true, most tax legislation would constitute a taking.[68]

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[63] "[T]here is no exclusive and permanent appropriation of *any portion* of plaintiff's land [and] since he is not wholly excluded from the use and enjoyment of his property, there is no 'taking' of the land in the ordinary sense." Richards v. Washington Terminal Co., 233 U.S. 546, 551–52 (1914). (Emphasis added.) *But see* Batten v. United States, 306 F.2d 584, 598 (10th Cir. 1962), *cert. denied*, 371 U.S. 955, *rehearing denied*, 372 U.S. 925 (1963), in which the dissenting opinion erroneously assumes that the Supreme Court in *Richards v. Washington Terminal, supra*, decided there had been a "constitutional taking by indirect interference" through the smoke concentrated on plaintiff. *Cf.* United States v. General Motors Corp.,* 323 U.S. 373, 378, 384 (1944). See also Sullivan v. Commonwealth,* 335 Mass. 619, 625, 142 N.E.2d 347, 352 (1957); Friendship Cemetery v. City of Baltimore, 197 Md. 610, 81 A.2d 57 (1951); 54 A.L.R.2d 768 (1957); McKee v. City of Akron,* 176 Ohio St. 282, 285, 199 N.E.2d 592, 594 (1964).

[64] In United States v. Causby, 328 U.S. 256, 261 (1946), counsel for the government agreed that if overflights made plaintiff's land uninhabitable, there would be a taking, and this would seem inescapable regardless of the cause if we define "uninhabitable" as meaning that the landowner has been involuntarily displaced rather than subjected to an aggravated case of discomfort. Compare Beseman v. Pennsylvania R.R., 50 N.J.L. 235, 236, 13 Atl. 164 (Sup. Ct. 1888), *aff'd*, 52 N.J.L. 221, 20 Atl. 169 (Ct. Err. & App. 1889); Taylor v. Chicago, M. & St. P. R.R., 85 Wash. 592, 594-95, 148 Pac. 887 (1915) (denying relief to an adjacent property owner despite the allegation that his property had been rendered "uninhabitable" by passing trains). See also Richards v. Washington Terminal Co., *supra* note 63, at 553, stating that the legislature "may not confer immunity from action for a private nuisance of such a character as to amount in effect to a taking of private property for public use." Six state cases were cited in support of this statement. One involved the discharge of slush on plaintiff's property. Sadlier v. City of New York,* 40 Misc. 78, 81 N.Y.S. 308 (Sup. Ct. 1903). Another related to an embankment on defendant's property that affected the foundation of plaintiff's house. Costigan v. Pennsylvania R.R.,* 54 N.J.L. 233, 23 Atl. 810 (Sup. Ct. 1892). The remaining four cases related to odors and noises from a gas tank and railroad yard facilities which should have been placed elsewhere, following Baltimore & P.R.R. v. Fifth Baptist Church, 108 U.S. 317 (1883), note 47 *supra*. In one of these, Pennsylvania R.R. v. Angel, 41 N.J. Eq. 316, 7 Atl. 432 (1886), which involved operation of a switchyard, the court stated, in a dictum, that smells and noise may constitute a taking of property. Two years later, however, the New Jersey Supreme Court limited the *Angel* case to its facts; *i.e.*, where a railroad was "doing certain acts which were obviously *ultra vires*." Beseman v. Pennsylvania R.R., *supra*, at 241. See also Roman Catholic Church v. Pennsylvania R.R., 207 Fed. 897 (3d Cir. 1913) (interpreting the law of New Jersey).

[65] Piggott, Principles of the Law of Torts 331 (1885). The sound wave argument is pressed in Lester, *Nuisance as a "Taking" of Property*, 17 U. Miami L. Rev. 537 (1963). See also comment in Martin v. Port of Seattle, 64 Wash. 2d 324 n.4, 391 P.2d 540 n.4 (1964). And compare Avery v. United States, 330 F.2d 640, 643–45 (Ct. Cl. 1964).

[66] Here one is thrown back to the broader interpretation of the Legal Tender Cases,* 79 U.S. (12 Wall.) 457, 551 (1871), in which the Court said that taking referred to "a direct appropriation, and not to consequential injuries resulting from the exercise of lawful power." The distinction between a "direct appropriation" by the government and "consequential damages" as the indirect result of action by the government, seems to be largely one of intent: "There can be no recovery . . . if the intention to take is lacking." Mitchell v. United States,* 267 U.S. 341, 345 (1925).

When the government admits an intention to take, it ordinarily commences an action to condemn. The cases coming before the courts, therefore, are usually instances in which the government has denied a taking, and the court has the problem of deciding whether some ambiguous action of the government demonstrates an intention to take. "Traditionally, we have treated the issue as to whether a particular governmental restriction amounted to a constitutional taking as being a question properly turning upon the particular circumstances of each case." United States v. Central Eureka Mining Co.,* 357 U.S. 155, 168 (1958). At least three different tests appear to have been applied depending on the type of property and nature of the government act:

(1) When the government commits an overt act that affects physical property, a taking will be assumed only when there has been an invasion resulting in exclusive possession by the government of some part of plaintiff's property. See, *e.g.*, United States v. Kansas City Life,* 339 U.S. 799 (1950); United States v. Dickinson,* 331 U.S. 745 (1946); United States v. Causby, 328 U.S. 256 (1946); Portsmouth Harbor L. & H. Co. v. United States,* 260 U.S. 327 (1922); United States v. Welch,* 217 U.S. 333 (1910).

(2) When the action of the government is by legislative proscription, a taking will

There have been two aviation cases involving flights over neighboring property in which the Supreme Court has held that there was a taking, *Causby v. United States* [69] and *Griggs v. County of Allegheny*.[70] In each of these cases there existed both the invasion and exclusive use which are required to effect a displacement of the property owners.[71] The "taking" was not based on the existence of an objectionable noise. The objectionable noise was there and may have caused damage, but damage alone does not constitute a taking.[72] In *Causby*, military aircraft regularly passed over the plaintiff's land at altitudes of eighty-three feet.[73] This effectively displaced the plaintiff: "The superadjacent air space at this low altitude is so close to the land that continuous invasions of it affect the use of the surface of the land itself." [74] In *Griggs* a similar displacement

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be assumed when the plaintiff is excluded by terms of the law from using some part of his property. Jankovich v Indiana Toll Road Comm'n,* 379 U.S. 487 (1965); Thompson v. Consolidated Gas Utilities Corp.,* 300 U.S. 55 (1937); Pennsylvania Coal Co. v. Mahon,* 260 U.S. 393 (1922). Compare United States v. Central Eureka Mining Co.,* *supra,* involving the exercise of war power.

(3) When the action of the government affects intangible property, a taking will be assumed if the government is "the direct positive beneficiary" of the loss suffered by the plaintiff. Armstrong v. United States,* 364 U.S. 40, 48 (1960). See also Cities Serv. Co. v. McGrath,* 342 U.S. 330 (1952). This is reminiscent of the implied contract theory referred to in note 58, *supra*, that was an essential feature of many of the earlier cases. *But see* Omnia Commercial Co. v. United States,* 261 U.S. 502 (1923).

[67] 17 S.W. L.J. 308, 310 (1963) (borrowing from 2 NICHOLS, EMINENT DOMAIN 259 (3d ed. 1950)). The same thought is expressed in the current edition of 2 NICHOLS, EMINENT DOMAIN § 6.3 (rev. 3d ed. 1963), which cites United States v. Dickinson, United States v. Causby, and Portsmouth Harbor L. & H. Co. v. United States, *supra* note 66, and quotes at length from Smith v. Erie R.R.,* 134 Ohio St. 135, 16 N.E.2d 310 (1938), an access case which says that "if there is no taking there can be no recovery of consequential damages."

Even cautiously worded generalizations in this field seem to lend themselves to distortion. Lewis stated: "Whenever the lawful rights of an individual to the possession, use or enjoyment of his land are in any degree abridged or destroyed *by reason of the exercise of eminent domain*, his property is, pro tanto, taken and he is entitled to compensation." 1 LEWIS, EMINENT DOMAIN 56 (3d ed. 1909). (Emphasis added.) At an earlier point, Lewis pointed out the several ways, other than exercise of eminent domain, government can use or interfere with private property, flatly concluding, "it seems objectionable to define eminent domain as the power to take property for a public use." *Id.* at 3-5. Yet in Morrison v. Clackamas County,* 141 Ore. 564, 568, 18 P.2d 814, 816 (1933), the Supreme Court of Oregon, in a case involving erosion of soil as the result of a bridge constructed on adjoining property, cited Lewis as supporting the statement that "any destruction, restriction or interruption of the common and necessary use and enjoyment of the property of a person *for a public purpose* constitutes a 'taking' thereof." (Emphasis added.)

Thus, Lewis' statement that there is a taking when, by *exercise of eminent domain*, rights in use and enjoyment of property have been damaged, is converted by the Oregon court into a conclusion that there is taking when there has been *any* interruption in the use and enjoyment of property for a public purpose. In this distorted form the rule became the support for Thornburg v. Port of Portland, 233 Ore. 178, 376 P.2d 100 (1962).

[68] In addition to taxes, four other types of non-compensable interference are listed in 1 LEWIS, *op. cit. supra* note 67, at 5.

The proponents of these broadened interpretations of "taking" never face up to the application of such a rule to personal property. If a United States mail truck dents the fender of a car, thereby lessening its value, is this too a "taking in the constitutional sense?"

Sax, *Takings and the Police Power,* 74 YALE L.J. 36, 67 (1964), suggests that a taking occurs "when an individual or limited group in society sustains a detriment to legally acquired existing economic values as a consequence of government activity which enhances the economic value of some governmental enterprise."

[69] 328 U.S. 256 (1946).

[70] 369 U.S. 84, *petition for rehearing denied,* 369 U.S. 857 (1962).

[71] According to 2 HARPER & JAMES, TORTS 1615 n.13 (1956), in *Causby* "the Court was driven either to find a taking or to deny relief, because of the unavailability of recovering on a nuisance theory at least before the Federal Tort Claims Act." See also Note, 59 MICH. L. REV. 968, 969 (1961). It now seems plain that the Federal Tort Claims Act would not permit recovery in such a case unless the military pilots were negligently or intentionally flying below the prescribed altitudes necessary for safe flight to and from the airport. See note 48 *supra*.

[72] "[D]amage alone gives courts no power to require compensation where there is not an actual taking of property." United States v. Willow River Power Co.,* 324 U.S. 499, 510 (1945). See also United States v. Central Eureka Mining Co.,* 357 U.S. 155, 168 (1958).

[73] United States v. Causby, 328 U.S. 256, 258 (1946). This was 67 feet above plaintiff's house, 18 feet above the highest tree on plaintiff's land.

[74] *Id.* at 265. The government abandoned the use of the easement after the end of the war. Causby v. United States, 75 F. Supp. 262 (Ct. Cl. 1948).

was found, with aircraft regularly passing on a glide path eleven feet above plaintiff's chimney.[75]

Both of these decisions were written by Mr. Justice Douglas. The rationale in each case was that a taking had occurred because the landowner had lost the use of the airspace immediately above his property to the extent it had been occupied by the government:

"[I]t is obvious that if the landowner is to have full enjoyment of the land, he must have exclusive control of the immediate reaches of the enveloping atmosphere. Otherwise buildings could not be erected, trees would not be planted and even fences could not be run. *The principle is recognized when the law gives a remedy in case overhanging structures are erected on adjoining land.* The landowner owns at least as much of the space above the ground as he can occupy or use in connection with the land." [76]

Although this seems clear enough, there are some who claim that what the Court really meant to say was that the noise made by the aircraft, not their use of the plaintiff's airspace, constituted the taking. For these disbelievers, a few more words may be added.[77] The opinion in Causby contains a fact statement of approximately five hundred words, in which the frequency and level of flights as well as the resulting noise, glare and risk of accidents are described. This fact statement is followed by a discussion of the relevant law for approximately three thousand words. The legal discussion is devoted entirely to the rights of landowners in the use of airspace above their property [78] and only two references are made to noise, each of which is inconsistent with the concept that the noise constituted a taking. The first, and very pertinent, reference serves to distinguish *Richards v. Washington Terminal*, where "property owners whose land *adjoined* a railroad line were denied recovery for damages resulting from the noise," whereas in *Causby* "the line of flight is *over the land*." [79] The second, and equally significant, reference is the statement that "The airplane is part of the modern environment of life, and the inconveniences which it causes are normally not compensable under the Fifth Amendment." [80]

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[75] Griggs v. Allegheny County, 369 U.S. 85, 86 (1962). "The question whether repeated aircraft overflights constitute a taking of particular property under the *Causby* and *Griggs* doctrine depends upon three factors: (1) the character of the land itself and (2) the altitude and (3) the frequency of the overflights." City of Atlanta v. Donald, 9 Av. Cas. 17439, 17443 (Ga. Ct. App. 1965).

[76] United States v. Causby, 328 U.S. 256, 264 (1946). (Emphasis added.) Once a taking occurs, the damage from noise is compensable. See cases cited in note 86 *infra*.

[77] The dissent of Mr. Justice Black (Mr. Justice Burton concurring) in *Causby*, contended the majority had wrongfully found that "noise and glare" constituted a taking. 328 U.S. at 269. See also Comment, 74 HARV. L. REV. 1581 (1961): "The compensable 'taking' . . . consists not in an appropriation of the landowner's property in a zone or column of airspace but rather in the creation of noise which substantially interferes with surface use and enjoyment." *Id.* at 1585. This questionable analysis was adopted a year later by the majority in Thornburg v. Port of Portland, 233 Ore. 178, 376 P.2d 100 (1962), and adopted in substance by Martin v. Port of Seattle, 64 Wash. 2d 324, 391 P.2d 540 (1964), *cert. denied*, 379 U.S. 989 (1965). See also Dunham, *Griggs v. Allegheny County in Perspective—Thirty Years of Supreme Court Expropriation Law*, in SUPREME COURT REVIEW 63, 88 (1962).

[78] "The path of glide for airplanes might reduce a valuable factory site to grazing land. . . . [T]he use of the airspace immediately above the land would limit the utility of the land and cause a diminution in its value," United States v. Causby, 328 U.S. 256, 262 (1946); "[T]he flight of airplanes, which skim the surface but do not touch it, is a smuch an appropriation of the use of the land as a more conventional entry upon it." *Id.* at 264; "[I]f the United States erected an elevated railway over respondents' land at the precise altitude where its planes now fly, there would be a partial taking, even though none of the supports . . . rested on the land. . . . While the owner does not in any physical manner occupy that stratum of airspace or make use of it in the conventional sense, he does use it in somewhat the same sense that space left between buildings for the purpose of light and air is used. . . . We think that the landowner, as an incident to his ownership, has a claim to it [the superadjacent airspace] and that invasions of it are in the same category as invasions of the surface." *Id.* at 264-65.

[79] *Id.* at 262. (Emphasis added.) According to Martin v. Port of Seattle, 64 Wash. 2d 324, 391 P.2d 540, 545 (1964), *cert. denied*, 379 U.S. 989 (1965), the surface displacement was of no importance: "The reliance placed upon the high noise level by the Supreme Court in both decisions, without detectable preoccupation with its angle of incidence, strongly indicates that the holdings are not limited to those instances where he aircraf passes directly over the land." See also Thornburg v. Port of Portland, 233 Ore. 178, 193, 376 P.2d 100, 107 (1962): "Whether expressed in so many words or not, the principle found in . . . Causby . . . is that when the government *conducts an activity upon its own land* which . . . is sufficiently disturbing to the use and enjoyment of *neighboring lands* to amount to a taking thereof, then the public . . . should bear the cost of such public benefit." (Emphasis added.)

[80] United States v. Causby, 328 U.S. 256, 266 (1946).

Similarly in the *Griggs* opinion written sixteen years later, after once stating the facts, Mr. Justice Douglas never again mentions noise. The decision in *Griggs* is based on the opinion in *Causby*:

> "[A]s we said in the *Causby* case, the use of land presupposes the use of some of the airspace above it. . . . Otherwise no home could be built, no tree planted, no fence constructed, no chimney erected. An invasion of the 'superadjacent airspace' will often 'affect the use of the surface of the land itself.' 328 U.S. at 265."[81]

If the plaintiffs in *Causby* and *Griggs* had merely been subjected to the noise they experienced, no recovery would have been allowed. This is the conclusion that was reached in *Richards* v. *Washington Terminal*, and it is also the conclusion in all the federal court cases on aviation. Flights over private land may constitute a taking if they are so low and so frequent as to be a direct and immediate interference with the enjoyment and use of the land below. However, no recovery is allowed nearby landowners for the damage to their property caused solely by the noise to which they are subjected.[82]

The distinction just described has been said to make hard law since compensation under the Constitution is provided to the landowner "directly under" the path of low-flying aircraft, but not to the landowner whose property is a "fraction of an inch" beyond the wing tip of the same aircraft.[83] This kind of argument makes two erroneous assumptions: first, that the nature of the injury to the two landowners is identical; and second, that whenever there is damage, compensation must be paid—an obviously unsupportable conclusion.[84] In answer to the first assumption, it can be accepted for purposes of argument that the noise suffered by the two landowners is exactly the same. The difference is that the landowner over whose property the flight path has been laid has lost the use of that airspace. The right to the exclusive use of a definable, although invisible, portion of his property has passed from him to the airport operator just as definitely as if a visible highway, railway, or canal had been laid out on the surface of his property. Although the flight path in the air (like the pipeline laid below the surface of the earth) is not visible, in each case the landlord has been displaced from some part of his property. He can no longer build in the flight path or safely fly kites in it. But, his neighbor whose property lies a "fraction of an inch" from the flight path may do whatever building or kite flying he chooses. Moreover, there are added risks of physical damage and injury imposed on the landowner whose property is subject to a flight easement.[85]

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[81] Griggs v. Allegheny County, 369 U.S. 85, 88–89 (1962). Mr. Justice Black dissented in both *Causby* and *Griggs*. In the first case, joined by Mr. Justice Burton, he claimed that there had been no taking—that the majority had based its decision on "noise and glare" which is "at best an action in tort." United States v. Causby, 328 U.S. 256, 269–70 (1946). In the second case, joined by Mr. Justice Frankfurter, he agreed with the Court there had been a taking "under the *Causby* holding," but asserted that the taking in *Griggs* was by the federal government and not by the defendant county (the airport operator) as decided by the majority. Mr. Justice Black again claimed that *Causby* based its finding of taking on "noise, vibration and fear caused by constant and extremely low overflights." Griggs v. Allegheny County, 369 U.S. 85, 91 (1962).

[82] See aviation cases in note 44 *supra*. "We are referred to no decisions holding that the mere maintenance of a nuisance effects a taking of adjoining or nearby property absent repeated physical invasions which are cognizable as the imposition of a servitude—the taking of an easement—rather than the tortious creation of a liability for which damages are recoverable under state law." Mosher v. City of Boulder, 225 F. Supp. 32, 36 (D. Colo. 1964). "We are cited to no decisions holding that the United States is liable for noise, vibration, or smoke without a physical invasion." Batten v. United States, 306 F.2d 580, 584 (10th Cir. 1962), *cert. denied*, 371 U.S. 955 (1963).

[83] Martin v. Port of Seattle, 64 Wash. 2d 324, 391 P.2d 540, 545 (1964), *cert. denied*, 379 U.S. 989 (1965). See also Thornburg v. Port of Portland, 233 Ore. 178, 198, 376 P.2d 100 (1962). The statement of the problem somewhat distorts the facts since where there has been a taking the easement acquired has been usually described as a right-of-way "1500 feet wide or 750 feet on either side of the center line of the runway" (*e.g.*, United States v. 765.56 Acres of Land, 174 F. Supp. 1,3 (E.D.N.Y. 1959)), thus providing a swath that is over a quarter of a mile wide, or eight times the breadth of the largest jet aircraft now in service. This is more than wide enough to cover normal deviations from the flight path and only rarely would an aircraft using the right-of-way pass a "fraction of an inch" from the property of adjacent landowners.

[84] See cases cited in note 72 *supra*. Compare Comment, 74 HARV. L. REV. 1581, 1583 (1961), urging a nuisance theory of relief: "Attention would be focused on the degree of actual interference, rather than on formalistic factors like the relationship of the flight path to a particular zone or column of air space." See also Spies & McCoid, *Recovery of Consequential Damages in Eminent Domain*, 48 VA. L. REV. 437, 444 n.27 (1962).

Thus, despite the assumed equality of the noise level, there is a very different impact on the two landowners. Both have been damaged, but in only one case has property been taken. And the federal constitution, along with half of the state constitutions, provides for compensation only when there has been a taking. Once the taking is established, the landowner may recover for consequential damages to the balance of his property, and this would include the damage from noise of aircraft utilizing the flight path.[86] This principle that a landowner whose property is taken may recover for consequential damages to his remaining property, but that a neighboring landowner may not recover for damage arising from the same objectionable activity, was well established long before noise from airplanes became a problem.[87]

In summary, then, when we are talking about real property, a taking occurs when landowners give up a portion of their property for use by the government or a public utility functioning under authority of the government. No legal difference exists between the low-level aircraft flight path which interferes with surface use of the land and the direct appropriation of the surface itself for railways, highways, canals or transmission lines, or the direct appropriation of the subsurface for the laying of pipelines. Those whose property is taken for any of these purposes can recover for the value of the property taken plus any consequential damages to the property that has not been taken, and this would include damages from noise and other objectionable activity resulting from the proposed use of the property taken. Neighbors, who have not had property taken, cannot recover for such consequential damages due to noise or other types of nuisances: "the doctrine has become so well established that it amounts to a rule of property, and should be modified, if at all, only by the lawmaking power." [88] This is the law under the federal constitution and is, or should be, the law in those states with similar constitutional provisions.[89]

B. The English Law

The law of England as it applies to these problems is of general interest for comparison with the federal patterns, and is of specific interest in understanding some of the state constitutions.

The common-law rule applicable to the noise of utilities functioning under legislative authority was stated by Mr. Justice Blackburn in a leading case, *Hammersmith & City Ry.* v. *Brand:*

"I think it is agreed . . . that if a person, not authorized by Act of Parliament so to do erected a railway or any other private road on his land, and then worked it by running locomotives and trains, or any other species of carriages, upon it, so that the vibration and noise . . . [annoyed] a neighbour, that injury would be a nuisance, and that neighbour would have a fresh cause of action against the maintainer of the way every time that the way was so worked . . . and he might . . . obtain an injunction. . . . But if, instead of making and maintaining a private way of his own, the owner of the land dedicated it as a *public* highway, and . . . the noise and vibration seriously affected the neighbours, I apprehend they would be without remedy. The common law would leave them suffering a private hardship for the public benefit." [90]

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[85] The resulting fear has been a major factual element in most taking cases. "If we had engine failure we would have no course but to plow into your house." Griggs v. Allegheny County, 369 U.S. 85, 87 (1962). See also United States v. Causby, 328 U.S. 256, 259 (1946); Bacon v. United States, 295 F.2d 936 (Ct. Cl. 1961); Johnson v. Airport Authority, 173 Neb. 801, 115 N.W.2d 426 (1962). Noise is more disturbing to individuals who associate the noise with risk of physical injury to themselves. "Eighty percent of those who complained of aircraft noise reported some fear in connection with aircraft, either fear of machines crashing on the house or else unwillingness to fly themselves." HANDBOOK OF NOISE CONTROL 10–12 (Harris ed. 1957). See also note 6 *supra*.

[86] See, *e.g.*, Boyd v. United States, 222 F.2d 493 (8th Cir. 1955); Mock v. United States, 8 Av. Cas. 18080 (Ct. Cl. 1964); Bowling Green Airport v. Long, 364 S.W.2d 167 (Ky. Ct. App. 1962); Johnson v. Airport Authority, 173 Neb. 801, 115 N.W.2d 426 (1962); Tennessee v. Rascoe, 181 Tenn. 43, 178 S.W.2d 392 (1944). This is frequently referred to as "severance damage." Spies & McCoid, *Recovery of Consequential Damages in Eminent Domain*, 48 VA. L. REV. 437, 441 (1962).

But any recovery for such consequential damages will be limited to those caused by activity on the property that has been taken. Campbell v. United States,* 266 U.S. 368 (1924); Boyd v. United States, *supra*; People v. Symons, 54 Cal. 2d 855, 357 P.2d 451 n.108 (1960).

[87] See Campbell v. United States,* *supra* note 86; Sadlier v. City of New York,* 185 N.Y. 408, 78 N.E. 272 (1906); Church v. Railroad, 36 Utah 238, 103 Pac. 243 (1909).

[88] Richards v. Washington Terminal Co., 233 U.S. 546, 555 (1914). See also United States v. Willow River Power Co.,* 324 U.S. 499, 506, 510 (1945): "The uncompensated damages sustained by this riparian owner on a public waterway are not different from those often suffered without indemnification by owners abutting on public highways by land."

[89] Legal principles applicable to municipalities may sometimes differ from those applicable to states. See, *e.g.*, Town of Amherst v. Niagara Frontier Port Authority, 19 App. Div. 2d 107, 241 N.Y.S.2d 247 (1963), *complaint dismissed for legal insufficiency*, 40 Misc. 2d 116, 242 N.Y.S.2d 831 (Sup. Ct. 1963).

The plaintiffs in *Hammersmith* had acquired their property before the railroad had been constructed. None of the plaintiffs' property had been used in the construction, and there was no showing of negligence in the operation of the railroad. It was admitted that the value of the plaintiffs' property had declined as a result of the running of the trains. The specific question before the House of Lords was whether the common-law rule had been altered by special legislation enacted in 1845, by which compensation was to be paid by railroads for "any lands taken or used for the purposes of the railway, or injuriously affected by the construction thereof." [91] After considering the purpose of the statute, the court denied the asserted claim on the basis that the compensation provided by Parliament was limited to damages occasioned by the construction of a railroad and did not give "any remedy to the Plaintiffs for damage occasioned to their house in the course of using the railway." [92]

This House of Lords decision remains the law in England today except to the extent modified by special acts of Parliament. Such an act has been adopted for the regulation of civil aviation (the Civil Aviation Act, 1949).[93] This act provides that no action for trespass or nuisance shall lie for normally conducted flights and no action for nuisance shall lie for noise and vibration caused by aircraft at airports but it imposes absolute liability for "material loss or damage" caused to persons or property on land or water by an aircraft in flight, taking off or landing.[94] Government aircraft are exempt from the act unless the Queen, by Order in Council, shall appy the act to such aircraft,[95] but no such Order in Council has issued. Furthermore, the Crown Proceedings Act of 1947 [96] relives the government from any liability for torts of the armed forces (which would include the operation of government aircraft) while training or maintaining their efficiency.

Returning for a moment to the law of England as it relates to noises other than those produced by aircraft, it will be observed that the rule is the same as that stated by the Supreme Court in *Richards v. Washington Terminal*. However, there is a difference between the two regimes in another respect which bears directly on the discussion to follow. In Engand, compensation is payable to an abutting owner whose property has declined in value as the result of losing a right of access to his property, or the stopping of a passageway used by him, or the narrowing of a road before his house.[97] Under the "taken" language of the federal constitution and of the states, such an abutting neighbor is ordinarily denied compensation.[98]

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[90] Hammersmith & City Ry. v. Brand, L.R. 4 H.L. 171, 195–96 (1869).

[91] Railway Clauses Consolidation Act, 1845, 8 & 9 Vict. c. 20, § 6. The pertinent part of this section provides that "the company shall make to the owners and occupiers of and all other parties interested in any lands taken or used for the purposes of the railway, or injuriously affected by the construction thereof, full compensation for the value of the lands so taken or used, and for all damage sustained by such owners, occupiers, and other parties, by reason of the exercise, as regards such lands, of the powers by this or the special Act, or any Act incorporated therewith, vested in the company. . . ." Also considered in the decision were the general provisions of the Lands Clauses Consolidation Act, 1845, 8 & 9 Vict., c. 18.

[92] At p. 206 the headnote reads: "The *Land Clauses Consolidation Act*, and the *Railways Clauses Consolidation Act,* do not contain any provisions under which a person whose land has not been taken for the purposes of a railway, can recover statutory compensation from the railway company in respect of damage or annoyance arising from vibration occasioned (without negligence) by the passing of trains, after the railway is brought into use, even though the value of the property has been actually depreciated thereby."

[93] 12 & 13 Geo. 6, c. 67 (1949).

[94] *Id.* §§ 40(1), 40(2) and 41(2). "'Material' loss or damage connotes, it is thought, injury to persons or property which is of a physical nature;" 5 HALSBURY'S LAW OF ENGLAND 246 n.k. (1953).

Section 41(2) provides: "No action shall lie in respect of nuisance by reason only of the noise and vibration caused by aircraft on an aerodome to which this subsection applies by virtue of an Order in Council under section eight of this Act. . ."

Pursuant to article 64 of the Air Navigation Order 1960, regulations have been issued providing that noise and vibration may be caused at licensed aerodomes when "(a) the aircraft is taking off or landing, or (b) the aircraft is moving on the ground or water, or (c) the engines are being operated" to check their performance, to warm them before flight or to insure the components of the aircraft are in satisfactory condition. Regulation 10 of Air Navigation (General) Regulations, 1960.

Despite the annoyance caused by noise of jet aircraft at England's principal airport "the demand, as reflected in rents and prices, was at least as great for houses close to the Airport as for those a few miles away." Report of the Committee on the Problem of Noise, Final Report, Cmd. No. 2056 at 64 (1963). The report recommended, however, that grants be made to cover a portion of the cost of soundproofing adjacent homes, and this recommendation has been recently adopted for a maximum of £100 ($280) per home. New York Times, March 11, 1965, p. 65, col. 7.

[95] Civil Aviation Act, 12 & 13 Geo. 6, c. 67, § 61 (1969).

[96] 10 & 11 Geo. 6, c. 44.

C. The State Constitutions

At the present time the state consitutions are of two types. Nearly half of the states have constitutional provisions similar to the federal, providing compensaion for property "taken" for public use. The other half provide compensation for property "taken or damaged," or contain other language with equivalent meaning.[99]

The manner in which these differences arose provides some assistance in interpreting the provisions themselves. Until 1870, the federal language had been uniformly copied by the states. In 1870 Illinois made the change, the first state to do so.[100] The impetus for the change was the great increase in rail and municipal highway construction following the end of the Civil War which changed the contour of many American cities. Property owners adjacent to this new construction frequently found that the grading had cut off their access to adjoining streets or that they had otherwise been adversely affected. The railroads and municipalities denied liability on the basis that there had been no taking, and this position was generally upheld by the courts. At the 1869 Illinois Constitutional Convention, it was urged that broader protection be afforded property owners by adding the word "damaged" to the constitutional provision for the purpose of providing the recovery available under English law which "has been well settled." [101]

The first two cases decided by the Illinois Supreme Court under the new language made it clear that the English rules were to be followed and that there was no intention to permit recovery for every conceivable type of property damage. In the first decision, the Illinois court held that a property owner whose land was adjacent to a street and who had lost his access to it as a result of municipal construction could recover for the decline in value of his property.[102] The court relied upon the English rule that a landowner has a property interest in such access.[103] However, in the second case, which was decided during the same term, the court refused to consider the claim of a landowner whose business was located several blocks away from a street which had been closed because under

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[97] Under the 1845 Acts of Parliament referred to in note 91 *supra*, a distinction was made between damage arising from authorized user for which no recovery was allowed (Hammersmith v. Brand) and damage to an abutting owner directly resulting from construction for which recovery was allowed. See. *e.g.*, M'Carthy v. Metropolitan Board of Works,* L.R. 7 C.P. 508 (1872) ; Beckett v. Midland Ry.,* L.R. 3 C.P. 82 (1867) ; East & West India Docks & B. Ry. v. Gattke,* 3 Mac. & G. 155 (1851) ; Chamberlain v. West End of London & C.P. Ry.,* 2 Best & Smith 605, 110 E.C.L.R. 604, *affirmed* at 617 (1863). Compare Ricket v. Metropolitan Ry.,* L.R. 2 H.L. 175 (1867), in which compensation was denied for a temporary interruption of access which substantially affected the business at plaintiff's hotel.

[98] See Transportation Co. v. Chicago,* 99 U.S. 635 (1879).

[99] This latter group includes: Alabama, Alaska, Arizona, Arkansas, California, Colorado, Georgia, Illinois, Kentucky, Louisiana, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, Pennsylvania, South Dakota, Texas, Utah, Virginia, Washington, West Virginia and Wyoming. In Alabama, Kentucky and Pennsylvania the "damaged" language is limited to action by municipalities and public utilities with the power of eminent domain. North Carolina has no state constitutional provision governing eminent domain, but property owners there are protected by the fourteenth amendment of the federal constitution, as well as by judicial interpretation of the state due process clause. Cormack, *Legal Concepts in Cases of Eminent Domain*, 41 Yale L.J. 221, 222 (1931).

[100] Prior to 1870 there had been some special state statutory provisions allowing recovery in limited instances for property damaged, and it is not uncommon today for a state with a federal type clause to make broader statutory provisions for compensation in connection with a specific construction project.

[101] 2 Illinois Constitutional Convention, Debates and Proceedings 1578 (1869–70).

[102] Rigney v. City of Chicago,* 102 Ill. 64 (1882). This was a definite expansion of the traditional rule, which denied compensation for loss of access unless part of the plaintiff's property had been taken and the taking itself resulted in a loss of access. Transportation Co. v. Chicago,* 99 U.S. 635 (1879). See discussion in Chicago v. Taylor,* 125 U.S. 161 (1888).

[103] The English rule allowing recovery for loss of access by an abutting property owner is stated in M'Carthy v. Metropolitan Board of Works,* L.R. 7 C.P. 508 (1872), a case cited by Rigney v. City of Chicago, *supra* note 102. *Rigney* was not, strictly speaking, an "abutting" property owner since his land was 220 feet from the street closed, but nevertheless he had lost a valuable access right and was treated by the Illinois court as though he were an abutting owner.

Illinois law (and the law of England) an owner has no property interest in non-abutting streets.[104] The test applied by the court was not whether there had been a decline in property values, which was claimed in both cases, but whether the decline was due to an established property right that had been destroyed. The first of these Illinois opinions contained the following statement, which was repeated verbatim in the second:

> "[T]o warrant a recovery it must appear there has been some direct physical disturbance of a right, either public or private, which the plaintiff enjoys in connection with his property, and which gives to it an additional value, and that by reason of such disturbance he has sustained a special damage with respect to his property in excess of that sustained by the public generally. . . . [I]t was the intention of the framers of the present constitution to require compensation to be made in all cases where, but for some legislative enactment, an action would lie by the common law." [105]

Several other states, following the example of Illinois, changed their constitutions to include the word "damaged" or its equivalent,[106] and the constitutions of most of the states admitted to the union after 1870 conained he broader terminology. An encyclopedic work would be needed to trace the history of the constitutional provisions in each of the states, but I have been able to find nothing to indicate any intention to allow a neighboring property owner to recover for loss due to noise.[107]

The changed language, it should be noted, did not say that compensation will be paid whenever a person has suffered damages, but was confined to situations in which his property has been damaged. The usual interpretation was that "damaging" was merely an extension of the idea of "taking." Thus "taking" was a physical process as it applied to real property: a taking did not occur unless there was a physical invasion of plaintiff's land. Similarly, "damaging" was also a physical process; a daamging did not occur unless there was either visible physical deterioration of plaintiff's land or loss of some right pertaining to his land which could be physically demonstrated, such as loss of access.[108] As already explained, this was also the pattern worked out in England. When the courts said that the addition of the word "damaged" was intended to restore the situation as it had existed under the common law, this is what was meant.[109]

This conclusion is supported by the preponderance of opinion among the states making the change that there is no right of recovery for noise from public improvements, whether operated by the government or those acting under government authority. The point appears to have been considered by twenty-two of the twenty-six states which have constitutions containing the term "damaged" or equivalent language. In fifteen of these states the courts adopted the federal rule (and the common-law rule) expressed in *Richards v. Washington Terminal*, that property owners adjacent to a right-of-way are required to bear without redress any depreciation in their property due to the noise resulting from its use.[110] In the remaining seven states having the term "damaged," there is a conflict in the decisions within the individual states, but in six of the seven states the more recent decisions indicate that noise is not compensable.[111] Finally, the few cases that have been found dealing with the loud noises made by trucks and cars moving on modern high-speed expressways unanimously hold that there can be no recovery.[112]

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[104] Chicago v. Union Bldg. Ass'n.* 102 Ill. 379 (1882), involving a suit for an injunction. The English rule denying recovery to the non-abutting property owner is stated in Ricket v. Metropolitan Ry.,* L.R. 2 H.L. 175 198–99 (1967).

[105] Rigney v. City of Chicago,* 102 Ill. 64, 81 (1882); Chicago v. Union Bldg. Ass'n,* 102 Ill. 379, 394 (1882).

[106] See 2 Nichols, Eminent Domain, § 6.44 (3d rev. ed. 1963).

[107] The history of the Virginia amendment, for example, closely follows that of Illinois. Virginia Constitutional Convention, Proceedings and Debates 714–15 (1902). In California, the change was made to permit recovery for loss of access. 3 Calif. Constitutional Convention 1189–90 (1878–1879). Two of the members of the court in Pennsylvania R.R. v. Marchant, 119 Pa. 541, 13 Atl. 690 (1888), *aff'd*, 153 U.S. 380 (1894), which denied recovery for noise, were Pennsylvania constitutional delegates.

[108] See, *e.g.*, Rigney v. City of Chicago,* 102 Ill. 64, 81 (1882) (there must be "some direct physical disturbance of a right . . . which gives to it an additional value"); Church v. Railroad, 36 Utah 238, 247, 103 Pac. 243, 247 (1909) ("there must be some physical interference with the property itself or with some easement which constitutes an appurtenant thereto"). Compare Tidewater Ry. v. Shartzer, 107 Va. 562, 59 S.E. 407 (1907). See Cormack, *Legal Concepts in Cases of Eminent Domain*, 41 Yale L.J. 221, 259–60 (1931), where it is suggested that the physical conception of "taking" should be abandoned and recovery allowed for any violation of the "legal relations" of an individual.

[109] See, *e.g.*, Rigney v. City of Chicago,* 102 Ill. 64 (1882); Pennsylvania R.R. v. Marchant, 119 Pa. 541, 561, 13 Atl. 690 (1888), *aff'd*, 153 U.S. 380 (1894).

[110] See McClung v. Louisville & N.R.R., 255 Ala. 302, 51 So. 2d 371 (1951); Arkansas State Highway Comm'n v. McNeill, 381 S.W.2d 425 (Ark. 1964) (highway noise); Hot Springs R.R. v. Williamson,* 45 Ark. 429 (1885), *aff'd*, 136 U.S. 121 (1890); People v. Symons, 54 Cal. 2d 855, 357 P.2d 451 (1960) (highway noise); Harrison v. Denver City Tramway Co., 54 Colo. 593, 131 Pac. 409 (1913); Austin v. Augusta Terminal R.R., 108 Ga. 671, 34 S.E. 852 (1899); Louisville Ry. v. Foster, 108 Ky. 743, 57 S.W. 480 (1900);

A clear statement of the predominant view appears in *Bennett* v. *Long Island R.R.*,[113] which, although arising in New York where the constitution follows the federal pattern, has been cited with approval a number of times by courts in states which have the broader constitutional language:[114]

"The rumble of trains, the clanging of bells, the shriek of whistles, the blowing off of steam, the discordant squeak of wheels in going around the curves, the emission of smoke, soot and cinders, all of which accompany the operation of steam cars, are undoubtedly nuisances to the neighboring dwellings in the popular sense, but as they are necessarily incident to the maintenance of the road, they do not constitute nuisances in the legal sense, but are regarded as protected by the legislative authority which created the corporation and legalized its corporate operations. Nor does the legal nature of such annoyances change as traffic increases them in volume and extent."[115]

As anyone knows who has heard the passage of a hundred-car freight train, the railroad cases cannot be explained away as differing in degree from the airway cases. The railway cases are characterized by claims of cracked walls, broken windows, and interrupted sleep.[116] In addition, the neighbors of railroads have been required to bear smoke, smells, sparks and cinders.[117]

Chesapeake & O. Ry. v. Gross, 19 Ky. L. Rep. 1926, 43 S.W. 203 (Ct. App. 1897); Louisville & S.R.R. v. Hooc, 18 Ky. L. Rep. 521, 38 S.W. 131 (1897); Matthias v. Minneapolis, St. P. & S. Ste. M. Ry., 125 Minn. 224, 146 N.W. 353 (1914); Romer v. St. Paul City Ry., 75 Minn.211, 77 N.W. 825 (1899); Dean v. Southern Ry., 112 Miss. 333, 73 So. 55 (1916); Randle v. Pacific R.R., 65 Mo. 325 (1877); Smith v. Northern Pac. Ry., 50 Mont. 539, 148 Pac. 393 (1915); Gram Constr. Co. v. Minneapolis, St. P. & S. Ste. M. Ry., 36 N.D. 164, 161 N.W. 732 (1916); Wunderlich v. Pennsylvania R.R., 223 Pa. 114, 72 Atl. 247 (1909); Pennsylvania R.R. v. Marchant, *supra* note 109; Pennsylvania R.R. v. Lippincott, 116 Pa. 472, 9 Atl. 871 (1887); Hyde v. Minnesota, D. & P.R.R., 29 S.D. 220, 136 N.W. 92 (1912); Board of Educ. v. Croft, 13 Utah 2d 310, 373 P.2d 697 (1962); Church v. Railroad, 36 Utah 238, 103 Pac. 243 (1909); Taylor v. Chicago, M. & St. P.R.R., 85 Wash. 592, 148 Pac. 887 (1915); DeKay v. North Yakima & Valley Ry., 71 Wash. 648, 129 Pac. 574 (1913); Smith v. St. Paul, M. & M.R.R., 39 Wash. 355, 81 Pac. 840 (1905).

[111] Compare decisions following the majority view: Thompson v. Kimball, 165 F.2d 677 (8th Cir. 1948) (construing law of Nebraska); Weiner v. Pennsylvania R.R., 292 Ill. App. 303, 10 NE.2d 981 (1937); Illinois Cent. R.R. v. Trustees of School, 212 Ill. 406, 72 N.E. 39 (1904); Aldrich v. Metropolitan W. Side Elevated Ry., 195 Ill. 456, 63 N.E. 155 (1902); Metropoitan W. Side Elevated Ry. v. Goll, 100 Ill. App. 323 (1902); Britt v. City of Shreveport,* 83 So. 2d 476 (La. App. 1955); Oil Fields & Santa Fe R.R. v. Treese Cotton Co.,* 78 Okla. 25, 187 Pac. 201 (1920); St. Louis, S.F. & T. Ry. v. Shaw, 99 Tex. 559, 92 S.W. 30 (1906); City of Lynchburg v. Peters, 156 Va. 40, 157 S.E. 769 (1931); See Gardner v. Bailey,* 128 W. Va. 331, 36 S.E.2d 215 (1945)—highway noise; with contrary views in the same state: Ill. Cent. R.R. v. Kuchle, 95 Ill. App. 185 (1901); Chicago, P. & St. L. Ry. v. Leah, 152 Ill. 249, 38 N.E. 556 (1894); Chicago, M. & St. P. Ry. v. Darke, 148 Ill. 226, 35 N.E. 750 (1893); Helmer v. Colorado, So. N.O. & P.R.R., 122 La. 141, 47 So. 443 (1908); Kayser v. Chicago B. & Q.R.R., 88 Neb. 343, 129 N.W. 554 (1911); Omaha & N.P.R.R. v. Janecek, 30 Neb. 276, 46 N.W. 478 (1890); St. Louis-San Francisco Ry. v. Matthews, 174 Okla. 167, 49 P.2d 752 (1935); Ft. Worth & R.G.R.R. v. Downie, 82 Tex. 383, 17 S.W. 620 (1891); Gainsville, H. & W.R.R. v. Hall, 78 Tex. 169, 14 S.W. 259 (1890); Tidewater Ry. v. Shartzer, 107 Va. 562, 59 S.E. 407 (1907); Fox v. Baltimore & O.R.R., 34 W. Va. 12 S.E. 757 (1890).

In addition, in a few states it is held that although there can be no recovery for the noise of passing trains, damages may be recovered for noise caused by railroad shops on the theory that they could be placed anywhere by the railroad—perhaps where it would annoy no one—and that the property owner required to bear the brunt of the annoyance produced by such a facility should be compensated for such damages as are not "common to the public at large." See, *e.g.*, Matthias v. Minneapolis, St. P. & S. Ste. M. Ry., 125 Minn. 224, 146 N.W. 353 (1914). This is not, however, the accepted rule in this country or in England. London, B. & S.C. Ry. v. Truman, H.L. 11 App. Cas. 45 (1885).

[112] See Arkansas State Highway Comm'n v. McNeil, 381 S.W.2d 426 (Ark. 1964); People v. Symons, 54 Cal. 2d 855, 357 P.2d 451 (1960); See Gardner v. Bailey,* 128 W. Va. 331, 36 S.E.2d. 215 (1945). See also Mathewson v. New York State Thruway Authority, 11 App. Div. 2d 782, 204 N.Y.S.2d 904 (1960), *aff'd*, 9 N.Y.2d 788, 174 N.E.2d 754 (1961).

[113] 181 N.Y. 431, 74 N.E. 418 (1905).

[114] See, *e.g.*, Smith v. Northern Pac. Ry., 50 Mont. 539, 148 Pac. 393 (1915); Church v. Railroad, 36 Utah 238, 103 Pac. 243 (1909); Taylor v. Chicago, M. & S.P.R.R., 85 Wash. 592, 148 Pac. 887 (1915).

[115] Bennett v. Long Island R.R., 181 N.Y. 431, 436–37, 74 N.E. 418, 420 (1905).

[116] See, *e.g.*, Richards v. Washington Terminal Co., 233 U.S. 546, 550 (1914); Taylor v. Chicago, M. & St. P.R.R., 85 Wash. 592, 594–97, 148 Pac. 887 (1915); cases cited in note 110 *supra*.

[117] See cases cited notes 110 and 116 *supra*. The decisions also deny relief for an increase in the level of noise over what was originally anticipated. See, *e.g.*, Thompson v. Kimball, 165 F.2d 677 (8th Cir. 1948); McClung v. Louisville & N.R.R., 255 Ala. 302, 51 So. 2d 371 (1951); Harrison v. Denver City Tramway Co., 54 Colo. 593, 131 Pac. 409 (1913); Louisville & N.R.R. v. Scomp, 124 Ky. 330, 98 S.W. 1024 (1907). See also Staton v. Atlantic Coast Line R.R., 147 N.C. 318, 61 S.E. 455 (1908).

Thus, in 1946 when the Supreme Court approached the issues in *Causby*, it had available to it two established principles of law: first, the rule that noise alone (absent negligence and the other special exceptions discussed earlier) does not constitute a ground for recovery under the federal constitution, the broadened state constitutions, the common law, or the statutory law of England; second, the rule that invasion and exclusionary possession of the airspace of a landowner does constitute an appropriation which requires the payment of compensation.[118] In *Causby* the Supreme Court fitted an airways noise case into the whole fabric of the law. I stress this because it would seem that the essence of Government under Law is a pattern that provides some assurance of reasonable consistency of treatment and not a patchwork derived from the whim of a Haroun al Raschid dispensing a case-by-case brand of "justice" without reference to any standard except his own.

D. Two Recent State Court Decisions

And this brings us to the recent decisions of two state courts involving aviation noises: *Thornburg* v. *Port of Portland*,[119] an Oregon case decided in 1962, and *Martin* v. *Port of Seattle*,[120] a Washington case decided in 1964. In Oregon the constitution follows the federal pattern; in Washington the constitution is in the broadened form, containing the words "taken or damaged." Despite the difference in constitutions, both of these states had previously decided that damage from noise alone, in the absence of negligence, did not constitute a compensable injury.[121] These earlier decisions had involved railways. However, when the courts of Oregon and Washington faced the issue of airway noise, the earlier holdings were simply ignored. A four-to-three majority in Oregon and a unanimous court in Washington held that the airway noise was a compensable injury. In each of the cases, persons who alleged that their property had been damaged by the noise of aircraft not shown to have been negligently operated and which did not pass over their property were held to have valid constitutional claims.

In *Thornburg*, the court decided that a "continuing and substantial interference with the use and enjoyment of property" is a taking, and that the issue of whether it is substantial enough to permit recovery will be for the jury to determine.[122] Since the accepted definition of nuisance is a "substantial" interference with "the use or enjoyment of land,"[123] *Thornburg* would, by this approach, convert every nuisance into a taking, a truly unique doctrine.[124] As the dissent pointed out, "Not a single Oregon case will support the theory that a mere nuisance can be considered a taking, as provided in our constitution, nor does any other jurisdiction where the language of the constitution is similar to ours hold that a mere nuisance can be considered a taking, nor does the majority cite any case so holding."[125]

The court in the *Martin* decision went even further. It decided that the interference did not have to be substantial,[126] and thus held that constitutional protection is afforded against aviation noises that are even below the level required for a nuisance. Indeed, the Washington court rejects the nuisance concept[127] and requires recovery "when the land of an individual is diminished in value for the public benefit. . . ."[128] The court did not even mention its earlier decisions dealing with railroads wherein it had flatly declared that railroad noises which "depreciate the value of adjoining private property" result in damage that "is purely consequential and is not recoverable."[129]

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[118] United States v. Causby, 328 U.S. 256, 264 (1946). See Hinman v. Pacific Air Transport Corp., 84 F.2d 755, 759 (9th Cir. 1936), *cert. denied*, 300 U.S. 655 (1937), where the court stated that in Portsmouth Harbor L. & H. Co. v. United States,* 260 U.S. 327 (1922), "the use or occupancy of the airspace, if it can be so considered, was under such circumstances as amounted to a taking of the surface also." See also Butler v. Frontier Telephone Co.,* 186 N.Y. 486, 491, 79 N.E. 716, 718 (1906): "The law regards the empty space as if it were a solid, inseparable from the soil, and protects it from hostile occupation accordingly."

[119] 233 Ore. 178, 376 P.2d 100 (1962).

[120] 64 Wash. 2d 324, 391 P.2d 540 (1964), *cert. denied*, 379 U.S. 989 (1965).

[121] See McQuaid v. Portland & V. Ry., 18 Ore. 237, 250, 22 Pac. 899, 904 (1889): "[T]he adjoining lot owner . . . will, doubtless, be obliged to submit to the ordinary inconvenience and consequences which the construction of a railroad track, and the moving of a locomotive and cars thereon, occasion,—be compelled to endure the smoke, noise and screeching which naturally result from the use of that character of vehicles; but they cannot be deprived of the right of ingress and egress to and from their premises, without compensation." For Washington cases, see note 110 *supra*.

[122] Thornburg v. Port of Portland, 233 Ore. 178, 194–95. 376 P.2d 100 (1962). On retrial, the jury found there had been no taking. Docket No. 245–004. Cir. Ct. Multnomah County, Feb. 17, 1964. An appeal has been entered.

[123] See 4 RESTATEMENT, TORTS § 822 (1939).

[124] For the origin of this fallacious standard, see note 67 *supra*.

[125] Thornburg v. Port of Portland, 233 Ore. 178, 207, 376 P.2d 100, 113–14 (1962). However, the dissent suggests (p. 213) that under Oregon law the plaintiffs may have a damage action against the municipality operating the airport "for the creation of a nuisance for the benefit of the public," citing Wilson v. City of Portland,* 153 Ore. 679, 58 P.2d 257 (1936), which involved negligent dumping of garbage in a ravine.

[126] Martin v. Port of Seattle, 64 Wash. 2d 324, 391 P.2d 540, 546–47 (1964), *cert. denied*, 379 U.S. 989 (1965).

Since neither *Thornburg* nor *Martin* reconciles its holdings with other decisions by the same courts, it is not possible to say what these cases mean. Did the court in *Martin* literally mean that "When the land of an individual is diminished in value for the public benefit, then justice, and the constitution, require that the public pay?" If that is the intent, damages may be recovered in Washington for enacting building restrictions or zoning requirements, for converting a two-way street into a one-way street, for narrowing sidewalks, for constructing neighborhood fire or police stations, or even for erecting a new lamppost, as well as for the noise of highways, railways and airways. And we may ask with reasonable curiosity if only land is to be protected by this new rule or whether personal property, which is also covered by the constitution, must be paid for when it has been "diminished in value for public benefit?" When a new bus franchise is authorized in the interest of public convenience and necessity, is compensation to be paid to the other holders of bus franchises and to the competitive rail and airlines who can show a decline in value of their licenses?

If only a small fraction of this is intended to be protected, the principle of socializing losses has been carried by the Washington court beyond anything previously known under American or English law.[130] But is that what is meant? It would not seem unreasonable to expect a court that makes such a drastic change in its constitutional concepts to have said so plainly. That was not done in *Martin*. As to its real meaning, not a clue is given—not a single case dealing with any subject other than aviation is mentioned throughout the entire opinion. Whether the court intended to make a separate rule for aviation but hesitated to say so because of the equal protection clause of the fourteenth amendment,[131] or whether it intended to change its constitutional standards, will presumably remain a mystery until the decision is tested in subsequent litigation in other causes.[132]

SUMMARY

In summarizing the subject of noise caused by the government or by government authorized utilities, I offer these conclusions:

First, *Richards v. Washington Terminal* still represents the federal law. A nuisance resulting from noise made by the government or by an entity operating pursuant to government authority does not constitute a taking even when it causes a decline in the value of neighboring property. Whether the noise emanates from a railroad, an express highway, an airway, or from a fire engine house makes no difference. To the extent the noise is a necessary incident of an activity sanctioned by law and is free from negligence, there is no right to recover damages.

Second, the preceding paragraph represents the federal rule; it is also the common-law rule and would appear to be the correct interpretation of the state constitutions which follow the federal pattern.[133] The word "taken" as used in the state constitutions, and as used in the ancestors of those constitutions, was not intended to provide recovery of damages for noise.

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[127] Although not mentioned in the decision, in Washington "nothing which is done or maintained under express authority of a statute, can be deemed a nuisance." WASH REV. CODE § 7.48.160 (1952).

[128] Martin v. Port of Seattle, 64 Wash. 2d 324, 391 P.2d 540, 547 (1964), *cert. denied*, 379 U.S. 989 (1965).

[129] Conger v. Pierce County, 116 Wash. 27, 198 Pac. 377 (1921). See also Washington cases cited in note 110 *supra*.

[130] Compare Note, 30 J. AIR L. COMM. 287, 291 (1964): "[T]he Supreme Court . . . is most likely to follow the lead of the Washington court . . . overruling *Batten* in the process."

[131] Although the Supreme Court has rejected previous contentions that the equal protection clause was violated by allegedly inconsistent judicial opinions, the cases in which the issue was raised suggest that some logical distinction between the opinions was drawn by the courts or was apparent on the face of the opinions. See, *e.g.*, Marchant v. Pennsylvania R.R., 153 U.S. 380 (1894), holding that equal protection of the laws under the fourteenth amendment was not denied by the distinction drawn by the Pennsylvania courts beteween a property owner damaged or by loss of access (to whom compensation was granted) and a property owner damaged by noise (to whom compensation was denied). Compare Beck v. Washington,* 369 U.S. 541, 554–55 and dissenting opinion at 568 (1962), also involving a decision of the Supreme Court of Washington.

[132] The petition of the Port of Seattle to the United States Supreme Court for a writ of certiorari [denied 379 U.S. 989 (1965)] did not make the equal protection argument.

Third, it has not been possible to examine in full the purpose that each of the individual states may have had when they incorporated the term "damaged" into their constitutions. To the extent this purpose has been discussed in the decisions of those states and in the few constitutional debates that have been referred to, there appears to have been no intention of providing compensation for the damage that may be caused by noise.[134] And surely an interpretation of a statute or constitution must be applied equally to all persons coming before the courts. When this is not done, as for example in *Thornburg* and *Martin*, the result must be condemned as a grave abuse of judicial power.

Obviously it cannot be contended that a court may not correct an erroneous interpretation once it has been shown to be erroneous. Neither can it be contended that constitutional provisions should be regarded as inflexible regardless of changes in economic and social conditions.[135] However, in the aviation cases it is apparent that no new legal problems have been created by changes in economic and social conditions. The legal problems are exactly the same as they have always been: where is the line to be drawn between compensable and noncompensable damage, and who is to draw it?

"Where is the line to be drawn? If property owners on Filbert street may recover, why not those on Arch street, and Race, and so on north and south, east and west, as far as the whistle of the locomotive can be heard, and its smoke can be carried? The injury is the same, it differs only in degree. And it does not stop here. The constitution does not apply to railroads merely. It affects all corporations clothed with the power of eminent domain, including cities, boroughs, counties, and townships; it is applicable to canals, turnpikes, and other country roads. If, by judicial construction, we extend the constitution to all the possibilities resulting from the lawful operation of a public work; to all kinds of speculative and uncertain consequential injures [*sic*], we shall find ourselves at sea, without chart or compass to guide us." [136]

In deciding where the line is to be drawn, consideration should be given to a number of subjects—the first that come to mind are the fairness of one line compared with another as it affects the individuals on whom the loss first falls and the cost to the government of socializing the loss. However, additional considerations are the ease of applying the rule, the importance of avoiding multiplicity of suits, and the ability of property owners and their lawyers to know when and how the rule applies. The common-law concept of physical invasion which was embodied in our constitutions is probably the easiest to apply of all possible choices, assuming that compensation is to be granted at all. The extended controversy over this relatively simple standard illustrates what would happen if a standard like that suggested by *Martin* were adopted.

What is clear is that the line has to be drawn somewhere, and wherever it is drawn there will be some who will argue persuasively that this results in injustice:

"[A] tyro thinks to puzzle you by asking where you are going to draw the line, and an advocate of more experience will show the arbitrariness of the line proposed by putting cases very near to it on one side or the other. But the theory of the law is that such lines exist, because the theory of the law as to any possible conduct is that it is either lawful or unlawful. As that difference has no gradation about it, when applied to shades of conduct that are very near each other, it has an arbitrary look." [137]

Where the line is to be drawn is considerably harder to answer than who should draw it. Here, it would seem that the line had already been drawn, and that it is only for the courts to determine whether particular cases fall on one side or the other. But even if that were not the case and the problem was solely one of what the rule should be, one might think that courts would be especially reluctant to embark on a novel course in a field involving so many considerations requiring the type of broad factual investigation and analysis characteristic of the legislative rather than the judicial function. The judicial expansion of constitutional language through interpretation is familiar enough, but we must not forget that this is largely either an effort to find a way to carry out the will of the people as expressed through the legislature or an attempt to accommodate a new social or economic fact within the framework of old words of general purport.[138] A court cannot lawfully expand the constitution simply because it disagrees with what the constitution says.

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[133] [I]t was the common law of England, and consequently of this country, when the constitutions were adopted, that if a private owner suffered necessary damage from a public improvement, but his land was not actually entered on or taken, it was *damnum absque injuria*," 2 NICHOLS, EMINENT DOMAIN § 6.38[1] (rev. 3d ed. 1963).

[134] See Wofford, *The Blinding Light—The Uses of History in Constitutional Interpretation*, 31 U. CHI. L. REV. 502 (1964).

[135] See Israel, *Gideon v. Wainright: The "Art" of Overruling*, SUPREME COURT REVIEW 211, 219–29 (1963).

[136] Pennsylvania R.R. v. Marchant, 119 Pa. 541, 558–59, 13 Atl. 690, 696 (1888), *aff'd*, 153 U.S. 380 (1894). Pennsylvania had previously added the "and damaged" language.

[137] This is a statement by Mr. Justice Holmes, but I can no longer remember the source. Similar statements by him appear in Louisville Gas & Elec. Co. v. Coleman * 277 U.S. 32, 41 (1928), and Holmes, *The Theory of Torts*, 44 HARV. L. REV. 773, 775 (1931).

"Of course we know full well that law must be administered by men, and that human judgment is an inevitable element in the application of law. But it is one thing to act according to one's personal predilections or choice, and a wholly different thing to come to one's own best conclusion in the light of his understanding of the law as it has been established by statute, decision, tradition, received ideals and standards, and all the other elements that go to make up our legal system." [139]

Fourth and finally, the one point on which courts appear agreed, regardless of the form of constitution, is that an injunction will not issue to restrain the government or a government-authorized entity from an activity which creates noise [140] so long as it is a necessary incident of an activity sanctioned by law and is not negligently conducted.[141] The courts will often give other reasons for withholding relief, but the result is that an injunction is regularly denied under these circumstances. If the courts were to adopt any other course, it would constitute an unreasonable interference with legislative authority.

A great service would be rendered potential litigants if the courts in all jurisdictions, federal and state, regardless of the constitutional language, would make the reason for their action clear. Because of the apparent reluctance of courts to state the proposition plainly, the point is constantly being relitigated.[142] It should be unequivocally laid to rest.

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[138] See Reich, *Mr. Justice Black and the Living Constitution,* 76 Harv. L. Rev. 673 (1963).

[139] Griswold, *Of Time and Attitudes—Professor Hart and Judge Arnold*, 74 Harv. L. Rev. 81, 92 (1960). See also Douglas, *Stare Decisis*, 49 Colum. L. Rev. 735, 754 (1949); and Breitel, *The Lawmakers,* 65 Colum. L. Rev. 749, 773 (1965).

[140] See, *e.g.,* Railroads: Osborne & Co. v. Missouri Pac. R.R., 147 U.S. 248 (1893); McClung v. Louisville & N.R.R., 255 Ala. 302, 51 So. 2d 371 (1951); Stetson v. Chicago & E.R.R., 75 Ill. 74 (1874). Pipelines, water and power companies: Transcontinental Gas Pipe Line Corp. v. Gault, 198 F.2d 196 (4th Cir. 1952); Hillside Water Co. v. Los Angeles,* 10 Cal. 2d 677, 76 P.2d 681 (1938); Gurnsey v. Northern Cal. Power Co.,* 160 Cal. 699, 117 Pac. 906 (1911). Construction of public airports: Jasper v. Sawyer, 3 Av. Cas. 18118 (D.C. Cir. 1953); Warren Township v. City of Detroit, 308 Mich. 460, 19 N.W.2d 134 (1944); State *ex rel.* Helsel v. Board of County Comm'rs, 37 Ohio Op. 58, 79 N.E.2d 698 (1947), *appeal dismissed,* 149 Ohio St. 583, 79 N.E.2d 911 (1948); Atkinson v. City of Dallas, 353 S.W.2d 275 (Tex. Civ. App. 1961). Operation from public airports: Smithdeal v. American Airlines, Inc., 80 F. Supp. 233 (N.D. Tex. 1948); Loma Portal Civil Club v. American Airlines, Inc., 39 Cal. Rptr. 708, 394 P.2d 548 (Sup. Ct. 1964); City of Phoenix v. Harlan, 75 Ariz. 290, 255 P.2d 609 (1953); Brooks v. Patterson, 159 Fla. 263, 31 So. 2d 472 (1947); Bourland v. City of San Antonio, 347 S.W.2d 660 (Tex. Civ. App. 1961). Operation from military airport: Western v. McGehee, 202 F. Supp. 287 (D. Md. 1962). Sonic boom tests: Coxsey v. Halaby, 231 F. Supp. 978 (W.D. Okla. 1964). A possible exception is Dlugas v. United Airlines Trans. Corp., 53 Pa. D. & C. 402 (C.P. 1944), in which an airline was enjoined from operating flights below one hundred feet not to exceed ten days a year in order to permit plaintiff's land to be farmed. The scope of the injunction in *Dlugas* is described in Anderson v. Souza, 38 Cal. 2d 825, 243 P.2d 497 (1952).

In states requiring compensation to be paid before a taking, an injunction may issue if this procedure has not been followed. See, *e.g.,* Stockdale v. Rio Grande Western Ry., 28 Utah 201, 77 Pac. 849 (1904).

[141] See, *e.g.,* Village of Blue Ash v. City of Cincinnati,* 173 Ohio St. 345, 182 N.E.2d 557 (1962) (municipality enjoined from condemning property of another municipality). Squaw Island Freight Terminal Co. v. Buffalo,* 246 App. Div. 472, 284 N.Y.S. 598 (1936), *modified,* 273 N.Y. 119, 7 N.E.2d 10 (1937) (city enjoined from improper discharge of sewage). Pennsylvania R.R. v. Angel, 41 N.J. Eq. 316, 7 Atl. 432 (1886) (railroad enjoined from ultra vires operation of switchyard in front of plaintiff's house). See note 64 *supra.*

[142] Consider, for example, the waste in two recent cases where this point was involved: Mathewson v. New York State Thruway Authority, 22 Misc. 2d 410, 196 N.Y.S.2d 215 (Sup. Ct. 1959), *aff'd,* 11 App. Div. 2d 782, 204 N.Y.S.2d 904 (1960), *aff'd,* 9 N.Y.2d 788, 174 N.E.2d 754 (1961) (action to enjoin night operations of trucks on New York thruway); Loma Portal Civic Club v. American Airlines, Inc., No. 259763, San Diego, Cal., Super. Ct., July 5, 1962, *reversed,* 37 Cal. Rptr. 253 (Ct. App. 1964), *rehearing denied,* March 31, 1964, *trial court's denial of injunction affirmed,* 39 Cal. Rptr. 708, 394 P.2d 548 (Sup. Ct. 1964), *petition for rehearing denied,* Sept. 11, 1964 (action to enjoin low flights at San Diego municipal airport).

So far as I am aware, this is the first attempt to draw together, on a broad scale, the cases dealing with the scope of the immunity of the government and government-authorized entities from legal action for objectionable noises or other nuisances. While I have been led at times to assert with a fair degree of positiveness what the law is or what the law should be, the article is cheerfully offered as a starting point for comment and criticism in this extremely interesting and difficult field.

EVA W. NAIR *v.* BENJAMIN D. THAW

ALCORN, HOUSE, THIM, RYAN AND COVELLO, JS.

Equity has the power to afford relief by injunction and damages for injury caused by a nuisance created by the unreasonable conduct on one's own property of an otherwise lawful activity. The determination of unreasonableness is essentially a weighing process, involving a comparative evaluation of conflicting interests.

The issuance of an injunction and the scope and quantum of injunctive relief rest in the sound discretion of the trial court.

Damages for physical discomfort and annoyance are not susceptible of exact pecuniary computation and must be left largely to the sound judgment of the trier.

The defendant's large residence was air-conditioned by a system of an industrial type designed to operate throughout the year. In connection with it was a cooling tower which was a separate structure one and a half feet from the residence and attached to it by pipes and wires. There were approximately seven such air-conditioning units installed in residences throughout the country. The plaintiff, who lived opposite the defendant, claimed that the cooling tower was not a building "ordinarily appurtenant" to a single-family residence and therefore violated the zoning ordinance. She also alleged that the operation of the air-conditioning unit resulted in unwarranted and excessive noise and was a nuisance. *Held:*

1. It could not be said as a matter of law that it was unreasonable for the trial court to conclude that the semidetached cooling tower was a building which is ordinarily appurtenant to a residence like that of the defendant.
2. The injunction issued by the court prohibiting the operation of the air-conditioning unit between 10 p.m. and 8 a.m. until the defendant reduced to a stated level the sound emanating from the tower did not transcend the proper limits of the court's discretion.
3. The damages of $3500 awarded to the plaintiff were not unreasonable.

Contrary to the plaintiff's contention, the court did not err in refusing to award exemplary damages, since it could not reasonably be concluded that the acts of the defendant were wanton or malicious and it was not alleged that they were.

The court did not err in its conclusion that the plaintiff failed to sustain her burden of proving her allegations that the high-frequency, pure tones found to exist in her home came from the defendant's residence. A ruling by the court that a report by three experts, made pursuant to an agreement of the parties, should be filed as an exhibit was, if erroneous, harmless, since the report merely confirmed the plaintiff's failure to prove her allegation. The claim of the plaintiff that she was deprived of an opportunity to cross-examine the three experts was of no avail in the absence of anything in the record to indicate that she asserted and was denied the right to such an examination.

There was no error in the refusal of the court to grant the plaintiff's request for a further period of ninety days within which to make additional tests to ascertain the source of the high-frequency tones.

Argued April 2—decided May 9, 1968

Action for an injunction to abate a nuisance caused by the operation of an air-conditioning system, for damages and for other relief, brought to the Superior Court in Hartford County and tried to the court, *Parskey, J.;* judgment for the plaintiff from which the plaintiff and the defendant appealed. *No error.*

George Muir, for the appellant-appellee (plaintiff).

Peter B. Sullivan, with whom was *Paul W. Orth*, for the appellee-appellant (defendant).

House, J. The parties own and occupy residences in an AA residence zone on opposite sides of Brookside Place in West Hartford. The defendant's residence cost in excess of $300,000. It is equipped with various machinery and equipment of the most modern and advanced design, including a glass-enclosed swimming pool and an elaborate air-conditioning system, which alone cost approximately $46,000. Most of the machinery and equipment serving the residence is located in a room the dimensions of which are approximately ten feet by twelve feet. Immediately in front of this room but in a separate structure one and one-half feet from the residence and attached to it by pipes and wires is a cooling tower 70½ inches wide, 93 inches long and 73¾ inches high; it is enclosed on the sides away from the house by a wooden fence about seven feet high. Without reciting a detailed description of this equipment and its operation, it suffices for us to note that it is not the usual air-conditioning system, which operates only in extremely hot weather, but is of a commercial or industrial type not found in the ordinary residence and is designed to operate continually. Although the ordinary, average-sized, single house in West Hartford would use an air-conditioning unit having approximately a 60,000-BTU capacity, the unit installed for the defendant's house has a 300,000-BTU capacity for refrigeration and a 350,000-BTU capacity for heating energy.

It is the operation of this equipment and the resulting allegedly unwarranted and excessive noise arising from its operation which gave rise to this action. It is the plaintiff's claim that the installation of the air-conditioning equipment is in violation of the West Hartford zoning ordinances and that its operation constitutes a nuisance which has injuriously affected her health, made it impossible for her to continue to occupy her home and impaired the value of her property. The plaintiff sought an injunction against the operation of the equipment as a nuisance installed in violation of the zoning ordinances, and she claimed $100,000 damages as well as general equitable relief.

The trial court rendered judgment awarding damages of $3500 to the plaintiff and enjoining the defendant from operating the cooling tower between the hours of 10 p.m. and 8 a.m. until he reduced the sound level emanating therefrom to be within certain prescribed limits, measured in decibels, on sound-level readings taken outside the plaintiff's bedroom. At the same time, the court filed a lengthy and detailed memorandum of decision in which it analyzed the problems involved and discussed the expert testimony and conflicts in evidence, its own observations based on visits to the premises and the controlling principles of law applicable to the facts. The court's detailed analysis and resulting judgment, however, satisfied neither party, and both have appealed from the judgment rendered.

The plaintiff has abandoned most of her assignments of error attacking the court's finding of facts. Her appeal, as briefed, chiefly claims error in the refusal of the court to find that the installation of the cooling tower was a violation of the zoning ordinances, in refusing to order mandatory removal of the tower and in refusing to enjoin its operation during the day and early evening hours as well as the nighttime hours. In addition, she claims error in the refusal of the court to grant her further opportunity to make tests in the defendant's residence to ascertain the source of high-frequency noises pervading her home, in receiving a report of three acoustic experts and in refusing to award exemplary damages to her.

In his appeal, the defendant, although he seeks affirmance of the judgment so far as it is attacked by the appeal of the plaintiff, seeks a reversal of the judgment, with judgment directed for him, on the basis of claimed errors in the finding of facts and on the claim that the court erred in conditionally enjoining the nighttime operation of the air-conditioning system and in awarding damages of $3500.

Since the court's finding of facts is basic to a consideration of the appeals, we have first examined the assignments of error directed to that portion of the finding. It is not subject to any material correction. It is futile to seek to have paragraphs of a draft finding or a counter finding substituted for the salient details of the finding where the evidence is conflicting and the finding as made has support in the evidence. *Winnick* v. *Parish*, 142 Conn. 468, 474, 115 A.2d 428. This is particularly so when facts are not admitted or undisputed and where the existence of a fact depends on questions of credibility. *Drazen Lumber Co.* v. *Casner*, 156 Conn. 401, 403, 242 A.2d 754; *Brockett* v. *Jensen*, 154 Conn. 328, 330, 225 A.2d 190.

In an AA residence zone in West Hartford, no buildings are permitted other than single-family residences "together with such other buildings as are ordinarily appurtenant thereto." West Hartford Zoning Regs. § 17.1.10 (1945 as amended). The word "building" is stated to include "any structure other than a boundary fence or wall." Id. § 17.1.1 (A). The court found that the cooling tower "is reasonably suited to the air-conditioning needs of defendant's residence" and concluded that the installation and maintenance of the tower "does not violate the West Hartford zoning ordinance." The zoning regulations do not prohibit an exterior cooling tower or detached or semidetached installation, and the court reasoned that, in the absence of express prohibitory language, an air-conditioning system which is suitable for the unique size of the defendant's unusual residence is permissible. Although no similar air-conditioning unit exists in any other residence in West Hartford, the court found that there are approximately seven such units installed in residences throughout the country. We cannot say as a matter of law that the court could not reasonably conclude that the semidetached cooling tower, which is reasonably suited to the air-conditioning needs of the particular residence, is a building which is ordinarily appurtenant to such a residence. We, accordingly, find no error in this conclusion of the court.

The plaintiff claims that the operation of the defendant's equipment constitutes a nuisance and that she is entitled to its abatement. The basis of her claim is twofold, the first being the noise emanating from the cooling tower and the other, a high-frequency, pure-tone or hum which the plaintiff and her husband first noticed about November, 1964, and which they assert emanates from the defendant's residence.

Before the hearing on the merits of the complaint, the Superior Court issued a temporary injunction prohibiting the operation of the cooling tower between the hours of 10 p.m. and 8 a.m. Following the hearing on the application for the temporary injunction, the defendant obtained from Carl W. Lemmerman, the plaintiff's acoustical expert, a detailed proposal for muffling or attenuating the sound coming from the cooling tower. Thereafter, and in substantial accordance with that expert's proposal and at a cost of $2400, the defendant installed baffles on the air intake and air discharge of the cooling tower and a partial housing over the motor. He later, at a cost of $160, installed a flexible hose on the water pipe in the equipment room to dampen any vibrations. After the installations, the plaintiff's expert took further readings at the plaintiff's request and informed the plaintiff that in his opinion there was no longer any nuisance. He was not again consulted by the plaintiff and was called as a witness for the defendant at the trial. Despite the alterations made by the defendant, the operation of the air-conditioning system continued to create annoying noise, to disturb the plaintiff and her husband, and to invade the peace and quiet of her home. The court expressly found the operation to be "annoying and irritating to persons of average sensibilities" and that it "continues to be so annoying notwithstanding the baffles installed by the defendant."

From the court's inspections of the plaintiff's premises, the voluminous testimony, including much expert opinion, and the test data, the court concluded that "the defendant has now eliminated the noise problem of the cooling tower during the day and early evening hours," when the neighborhood background noise level is higher than it is at night, and that a person of average sensibilities would not then be annoyed. It was on the basis of this finding that the court concluded that the injunction against the operation of the cooling tower be limited to prohibit its operation between 10 p.m. and 8 a.m. until the defendant reduced the sound level emanating from the tower so that a sound-level reading taken between the hours of midnight and 3 a.m. outside the plaintiff's bedroom window with the cooling tower on showed a reading of no higher than thirty-five decibels at the 500- and 250-cycle band, forty-five decibels at the 125-cycle band and fifty decibels at the 63-cycle band.

"For over one hundred years in this state, we have recognized the general power of equity to afford relief by injunction and damages for injury caused by a nuisance created by the unreasonable conduct on one's own property of an otherwise lawful activity. *Whitney* v. *Bartholomew*, 21 Conn. 213; *Bishop* v. *Banks*, 33 Conn. 118; *Hurlbut* v. *McKone*, 55 Conn. 31, 10 A. 164; *Heppenstall Co.* v. *Berkshire Chemical Co.*, . . . [130 Conn. 485, 488, 35 A.2d 845]; *Cyr* v. *Brookfield*, 153 Conn. 261, 216 A.2d 198." *Krulikowski* v. *Polycast Corporation*, 153 Conn. 661, 666, 220 A.2d 444. "It is the duty of every person to make a reasonable use of his own property so as to occasion no unnecessary damage or annoyance to his neighbor. If the use is unreasonable the law will hold him responsible." *Nailor v. C. W. Blakeslee & Sons, Inc.*, 117 Conn. 241, 245, 167 A. 548; *Marchitto v. West Haven*, 150 Conn. 432, 437, 190 A.2d 597. "Determining unreasonableness is essentially a weighing process, involving a comparative evaluation of conflicting interests in various situations according to objective legal standards." Restatement, 4 Torts § 826, comment b.

As we said in *Krulikowski v. Polycast Corporation*, supra, 669, "[t]he issuance of an injunction and the scope and quantum of injunctive relief rests in the sound discretion of the trier." See also 39 Am. Jur. 330, Nuisances, § 47; Spater, "Noise and the Law," 63 Mich. L. Rev. 1373, 1380. There is nothing in the record in the present case which would justify us in holding on either the plaintiff's appeal or the defendant's appeal that the injunction as issued transcends the proper limits of the court's discretion exercised after a full hearing and after consideration of a mass of evidence and conflicting expert scientific opinion.

Nor do we find any error in the award of damages to the plaintiff in the amount of $3,500. The plaintiff claims that the court erred in refusing to award exemplary damages. "Concerning this, it is enough to say that the plaintiff did not allege in . . . [her] complaint any wanton or malicious misconduct of the defendant, or negligence tantamount to such misconduct. Further, no facts have been found from which could be reached a reasonable conclusion that the acts of the defendant were of such a kind." *Killan v. Bolster*, 96 Conn. 693, 694, 115 A. 469. The defendant in his appeal asserts that the award was excessive. The plaintiff was entitled to recover for the physical discomfort and annoyance caused by the defendant's unreasonable use of his air-conditioning equipment so far as it materially affected the comfortable enjoyment and occupancy of her home and interfered with her use and enjoyment of her property. *Nailer v. C. W. Blakeslee & Sons, Inc.*, supra, 246. "In the nature of things such damages are not susceptible of exact pecuniary computation and must be left largely to the sound judgment of the trier. . . . [W]e find nothing in the record which would justify us in concluding that the amount which the trial court has fixed is not reasonable compensation." Ibid.; *Krulikowski v. Polycast Corporation*, supra, 670.

The remaining points raised by the appeal concern the plaintiff's claim that a pure-tone or high-frequency hum or sound of constant pitch was audible in her home. By amendment to her complaint in December, 1965, she alleged that this was a separate and distinct sound emanating from the defendant's property, causing annoyance to her. Whether such a sound existed and, if it did, whether it emanated from the defendant's residence was a strongly contested issue. The plaintiff, whose ear, nose and throat specialist testified that she has a highly acute sense of hearing, and her husband both testified that the noise existed. On the other hand, the court found that the following persons who were present at the trial and had been on the defendant's premises from time to time did not hear the hum at any time or place: the court; the defendant; Robert M. Hoover, the defendant's expert; Carl W. Lemmerman, the plaintiff's former expert; Lewis S. Goodfriend, the plaintiff's expert retained during the trial; two neighbors; and an employee of the Hartford Electric Light Company. The latter on one occasion shut off all power to the defendant's premises at the transformer on the utility pole at the street edge of the plaintiff's premises, but the plaintiff's husband still claimed to hear the noise.

At the conclusion of the trial, and at the suggestion of the court made during a chamber's conference, it was agreed between the attorneys for the plaintiff and the defendant that further tests should be made by the three experts who had already testified on the trial, one representing the defendant and the other two representing the plaintiff, for the purpose of attempting to ascertain the source of the high-frequency, pure tones heard in the plaintiff's residence. The court expressly found that the understanding was that the equipment, method, and techniques of conducting the test would be left to the experts of both parties and that the report would be filed with the court if the experts agreed on a conclusion. The unanimous report of the three experts concluded that instruments indicated the presence of several, pure, tone-like signals in and around the plaintiff's residence which were below the sound-pressure level of zero decibels and that by turning off the electric power and gas at the defendant's residence "it has been conclusively proved that the above-mentioned signals do not emanate from the Thaw residence, since all the signals still persisted."

At a further hearing, over the objections of the plaintiff, the court received the report, which it marked as a court exhibit. Although the plaintiff does not contest the finding that there was an off-the-record agreement that the test be made by the three experts as suggested by the court, she claims that, contrary to the court's finding, the stipulation did not include an agreement that the report, if unanimous, should be filed with the court as an exhibit in the case. This aspect of the case once again illustrates the hazards of making off-the-record stipulations relative to matters arising in the course of a trial. The court and counsel can best assure themselves of protection from misunderstanding and faults of recollection by having a transcript available for review by this court and by not bypassing the services of the court reporter. Even with a transcript, however, the ultimate responsibility for seeing that the record conforms to the fact rests on the trial court subject to proper proceedings for rectification pursuant to §§ 675 and 695 of the Practice Book. *Whiteside* v. *State*, 148 Conn. 77, 83, 167 A.2d 450; *Papallo* v. *Meriden Savings Bank*, 128 Conn. 289, 291, 22 A.2d 637.

The claim of the plaintiff that she was deprived of any opportunity for cross-examination of the three witnesses who submitted the report avails her nothing in the absence of anything in the record to indicate that she asserted and was denied the right to such an examination. We find no error in the conclusion of the trial court that the plaintiff failed to sustain her burden of proving that the high-frequency, pure tones found to exist in her home emanated from the defendant's residence. Even if the admission of the exhibit was erroneous, the ruling was harmless because the report did no more than confirm what the plaintiff's evidence failed to prove, namely, that the high-frequency tones came from the defendant's house.

One further reason of appeal remains. The final hearing in the case was concluded on March 28, 1966. Subsequently in her brief dated June 27, 1966, the plaintiff requested a further period of ninety days within which to make still further tests for the purpose of ascertaining the source of the high-frequency noises. The plaintiff claims that the court was in error in refusing to grant this request. We find no error in its ruling, which was based on the right of the defendant to have the litigation terminated.

There is no error on either appeal.

In this opinion the other judges concurred.

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NOISE AS A NUISANCE

(By William H. Lloyd†)

Some few years ago when giving that part of the course on Equity Jurisprudence relating to torts, the writer gave an examination question abstracted from a recent decision of the Court of Chancery of New Jersey. It was the usual nuisance case: a complaint by an adjoining owner of noise, dust and vibration. One student included in his answer the following statement: "The test then is whether this conduct interferes with ordinary comfort, not according to some fanciful standard but according to the plain and sober manners of an English gentleman." Such sturdy loyalty to the home of the common law and one of its most estimable products may have commendable elements in a chaotic world; but the deportment of the English countryside seems a whimsical test to apply in a mill town of northern New Jersey best known for bootleggers and communists. Nevertheless our student had the semblance of a thought: he was seeking to recall an oft quoted *dictum* of Vice-Chancellor Knight-Bruce: " . . . ought this inconvenience to be considerd in fact as more than fanciful, more than one of mere delicacy or fastidiousness, as an inconvenience materially interfering with the ordinary comfort physically of human existence, not merely according to elegant or dainty modes and habits of living, but according to plain and sober and simple notions among the English people?"[1]

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[1] Walters v. Selfe, 4 De G. & S. 315 (1851).

This impressive *dictum* was quoted in *Soltau* v. *DeHeld*,[2] a case read in course; in fact, it has been referred to so frequently that a judge in a recent English case expressed some gratification that they had got along without mentioning it. Our student was justified in recalling it, and his emendation may be taken as a mild offset to Napoleon's sneer at the English as a nation of shopkeepers. Indeed, if gentlemen are as cheap as Sir Thomas Smith implies, and include all who can live idly without manual labor,[3] perhaps the emendation was not as commendatory as it seems. In fact, a proper sense of humility would recommend the modest limitations indicated by the Supreme Court of Washington: "The nuisance and discomfort must affect the ordinary comfort of human existence as understood by the American people in their present state of enlightenment." [4]

In attempting to separate sound from other forms of nuisance and discover if possible what kind of complaints are likely to receive sympathetic consideration from the courts, general statements, *dicta*, and definitions are not very helpful. Nuisance, which means literally annoyance, may be described as a wrong done to one by unlawfully disturbing him in the enjoyment of his property or in the exercise of a common right.[5] But the term eludes exact definition because, as has been well said, "the controlling facts are seldom alike, and each case stands on its own footing. We are not aided by the classification into public and private nuisances, because the difference between them does not depend on the nature of the thing done, but on the fact that one affects the public at large and the other a limited number only. . . . The injury may be to person or property, to health, comfort, safety or morality. It may be a crime." [6] What amount of annoyance or inconvenience, then, will constitute a nuisance is largely a question of degree; the injury of course must be real and substantial and in the case of private nuisance must be such as to interfere materially with ordinary physical comfort or the reasonable use of property. But what is ordinary comfort to the "sober English people" or the Americans "in their present state of enlightenment"? In spite of the inclination of ultra modernists to lift their eyebrows at cases, we must go to them for information: they are, in fact, all we have, except a confused multitude of local ordinances which tell us something about the kinds of petty annoyances that have provoked restrictive community action, but nothing about the consensus of opinion to which such restrictions may be attributed.

So far as private nuisance is concerned there is little to be learned from the early reports that is of much value in solving the problems of the age of mechanical invention. The cases deal, commonly, with injuries relating to real property or its appurtenances, such as stopping or interfering with rights of way, flooding the land by the diversion of waters or water courses, or corrupting the air with noisome smells, so as to render one's dwelling house unwholesome and uncomfortable.[7] This last group may be regarded as the forerunner of a well known line of decisions that have followed the industrial revolution, which preserve and elaborate a principle found in the early law that the fact that an occupation was commendable in itself and carried on in a proper manner did not alone justify substantial damage to property or the infliction of material discomfort upon residents of a neighborhood. Such cases frequently present a complex of nuisances, noise, smoke, dust, vibration and offensive odors; pleaders naturally make out as dark a story as possible, although it is admitted that no particular combination of annoyances is essential.[8] In this type of litigation noise is frequently a factor, but not the only or indeed the leading factor in an accumulation of disturbances. An effort will be made as far as possible in this survey to confine the discussion to cases where noise was the sole or at least the predominant factor in inducing action by the court. For it is generally admitted that noise alone may constitute a nuisance, although in determining whether it is in fact such a nuisance as to entitle the complaining party to relief at law or in equity, the character, volume, time, place and duration of its occurrence, as well as the locality, must be taken into consideration.[9]

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[2] 2 Sim. (N. S.) 133 (1851).

[3] COMMONWEALTH OF ENGLAND (1583) Bk. 1, c. 20. 1 BL. COMM. *406.

[4] Everett v. Paschall, 61 Wash. 47, 52, 111 Pac. 879, 881 (1910). See also Stevens v. Rockport Granite Co., 216 Mass. 486, 104 N. E. 371 (1914); Attorney-General v. Doremus, 11 Del. Ch. 277, 101 Atl. 868 (1917); Kroecker v. Camden Coke Co., 82 N. J. Eq. 373, 88 Atl. 955 (1913).

[5] POLLOCK, TORTS (9th ed. 1912) 412; 21 AM. & ENG. ENC. OF LAW (2d ed.) 682, quoted in Johnson v. New York, 109 App. Div. 821, 96 N. Y. Supp. 754 (1905).

[6] Melker v. New York, 190 N. Y. 481, 488, 83 N. E. 565, 567 (1908); District of Columbia v. Totten, 55 App. D. C. 312 (1925). See also City of Pana v. Washed Coal Co., 260 Ill. 111, 102 N. E. 992 (1913); Cumberland Corp. v. Metropoulos, 241 Mass. 491, 135 N. E. 693 (1922); Wier's Appeal, 74 Pa. 230 (1873). For the eminent domain cases see Notes (1906) 1 L. R. A. (N. S.) 49, (1908) 17 L. R. A. (N. S.) 1054.

[7] Batten's Case, 9 Co. 53 (1610); Aldred's Case, 9 Co. 57 (1610); Morley v. Pragnell, Cro. Car. 510 (1639); FITZHERBERT, NATURA BREVIUM *183; 16 VINER, ABRIDGMENT (1st ed. 1743) 26; 1 COMYN, DIGEST (4th ed. 1793) 303; 3 BL. COMM. *216; 1 ROLLE, ABRIDGMENT (1668) 88.

In examining the authorities in which industrial noises are considered it is noticeable at once that few of the complaints involve the great plants of nationally important heavy industries, as is not uncommon in the smoke and gas cases.[10] Chemical fumes and smoke are annoying at greater distances than noise, and it is usual to find the larger plants situated in neighborhoods fully industrialized or purposely placed in comparative isolation. The enterprises involved, in complaints concerning noise, while frequently of local importance, are usually of moderate size and of a type that may be operated successfully within, or upon the border of, a residential section. On the other hand, occasionally, residential building operations spread into a partially industrialized area. Such fluctuations seem inevitable in communities still in a state of development. Zoning, while helpful, is not decisive. It has been held recently in Massachusetts, that a zoning ordinance which impresses an industrial character upon a neighborhood does not sanction practices not naturally incidental to ordinary and reasonable use.[11] It has been said that where industrial works are collected in an appropriate locality and are prudently carried on during working hours, noise inseparable from such enterprises must be endured by those who by choice or necessity live in the vicinity.[12] But although not entitled to the same peace and quiet as in a district strictly residential, the householder can still insist that the business be conducted in a reasonable manner, with due regard to his rights as one who dwells in a manufacturing district.[13]

Indeed if the law were otherwise he could be driven from his home without redress. "One who settles in a district, which possesses natural resources of a special kind, cannot prohibit the development of those resources merely because it may interfere in some degree with personal satisfaction or aesthetic enjoyment. No one can move into a quarter given over to foundries and boiler shops and demand the quiet of a farm. On the other hand, the noisy or noisome factory cannot with immunity invade territory stamped by use for residence." [14] Just as in international law there must be compromises with neighbors whom to some it would be preferable to exterminate, so in these minor conflicts compromises that do not always meet the tests of logic are unavoidable. Necessarily they are based on practical considerations. Highly nervous and oversensitive persons are not afforded exceptional immunity or protection. "Equity is sometimes said to act upon the conscience of the individual," observes a federal judge, "but that phrase does not mean that it will enforce the golden rule in favor of one individual, against another, . . ."[15]

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[8] "Un tan house est necessary, car touts wear shoes: et uncore ceo poit estre pull down, &c. si est erect al nusance l'auter: et issint de glass-house." Jones v. Powell, Palm. 536 (1628); Baltimore & P. R. R. v. Fifth Baptist Church, 108 U. S. 317, 2 Sup. Ct. 719 (1883); Judson v. Los Angeles Gas Co., 157 Cal. 168, 106 Pac. 581 (1910); Simon v. Detroit Motor Valve Co., 233 Mich. 17, 206 N. W. 336 (1925); Davidson v. Isham, 9 N. J. Eq. 186 (1854); Roessler, *etc.* Co. v. Doyle, 73 N. J. L. 521, 64 Atl. 156 (1906); Fish v. Dodge, 4 Denio 311 (N. Y. 1847); Bohan v. Port Jervis Gas Light Co., 122 N. Y. 18, 25 N. E. 246 (1890); Walters v. Selfe, 4 De G. & S. 315 (1851); Bamford v. Turnley, 3 B. & S. 66 (1862); St. Helens S. Co. v. Tipping, 11 H. L. Cas. 642 (1865).

[9] Episcopo v. Olivere, 15 Del. Ch. 220, 135 Atl. 482 (1926); Damadio v. Levinsohn, 111 N. J. Eq. 84, 161 Atl. 504 (1932); Dittman v. Repp, 50 Md. 576 (1878); Stevens v. Rockport Granite Co., *supra* note 4; Roukovina v. Island F. C. Co., 160 Minn. 335, 200 N. W. 350 (1924); Krocker v. Westmoreland P. Mill, 274 Pa. 143, 117 Atl. 669 (1922); Powell v. Bentley, 34 W. Va. 804, 12 S. E. 1085 (1891); Bradley v. Gill, Lutw. 69 (1688).

[10] For example, Georgia v. Tennessee Copper Co., 206 U.S. 230, 27 Sup. Ct. 618 (1907), 237 U. S. 474, 35 Sup. Ct. 752 (1915), 240 U. S. 650, 36 Sup. Ct. 465 (1916); Hulbert v. California Portland Cement Co., 161 Cal. 239, 118 Pac. 928 (1911); Sullivan v. Jones & Laughlin Steel Co., 208 Pa. 540, 57 Atl. 1065 (1904), 222 Pa. 72, 70 Atl. 775 (1908).

[11] Beane v. H. K. Porter, Inc., 280 Mass. 538, 182 N. E. 823 (1932). Accord: Eaton v. Klimn, 217 Cal. 362, 18 P. (2d) 678 (1933); Marshall v. Holbrook, 276 Mass. 341, 177 N. E. 504 (1931).

[12] Monlezun v. Jahncke Dry-Docks, Inc., 163 La. 400, 111 So. 886 (1927); Lohmuller v. Kirk, 133 Md. 78, 104 Atl. 270 (1918); Gilbert v. Showerman, 23 Mich. 448 (1871); Roy v. Chevrolet Car Co., 262 Mich. 663, 247 N. W. 774 (1933); Hauser v. Kracuter & Co., 97 N. J. Eq. 413, 129 Atl. 473 (1925); Sparhawk v. Union Pass. Ry., 54 Pa. 401 (1867); Austin v. Converse, 219 Pa. 3, 67 Atl. 921 (1907); Hafer v. Guyman, 7 Dist. R. 21 (Pa. 1807); Crossett v. Standard Ice Mfg. Co., 27 Dist. R. 26 (Pa. 1918).

[13] Dittman v. Repp, 50 Md. 516 (1878); Robinson v. Baugh, 31 Mich. 290 (1875); Easteott v. Metal Craft Co., 254 Mich. 513, 236 N. W. 847 (1931); Collins v. Wayne Iron Works, 227 Pa. 326, 70 Atl. 24 (1910), Quinn v. American Spring Co., 203 Pa. 152, 141 Atl. 855 (1928); Rushmer v. Polsue Alfieri, Ltd., [1966] 1 Ch. 234.

[14] Stevens v. Rockport Granite Co., *supra* note 4, at 488, 104 N. E. at 373. See also Nugent v. Melville Shoe Corp., 280 Mass. 469, 182 N. E. 825 (1932); Ebur v. Alloy Metal Wire Co., 304 Pa. 177, 155 Atl. 280 (1931). A right to make a noise is not acquired by long user unless during the period of user the noise was an actionable nuisance. Sturges v. Bridgman, 11 Ch. D. 852 (1879).

As to the particular sounds that have furnished grounds for litigation, it will be found that those produced in the fabrication of metals are most conspicuous, owing to the pounding and hammering inseparable from such occupations. There are many suits involving iron mills, machine shops, forges and foundries,[16] but, of course, the cases are by no means confined to these obvious instances of unusual disturbance, Jewelers and silversmiths have been charged with similar nuisances.[17] A well known decision is the *Appeal of the Ladies Decorative Art Club.*[18] In that case the defendants, who were enjoined from maintaining a nuisance, conducted a school of industrial art, in a house which was one of a row of dwellings in a residential section, to the discomfort of an adjoining owner. The disturbance consisted in the tapping and hammering incidental to the instruction in wood carving and metal chasing. The buzzing, whirring and grinding sounds of machinery have been a frequent source of complaint when excessive and ill timed.[19] It is unnecessary to particularize, but printing establishments[20] and plants for the manufacture of dairy products and ice may be mentioned as light industries usually located close to populous district.[21] Objections to garages and gas filling stations have been so frequent that they call for separate treatment.[22] In many instances it is not so much the plant itself as the mode of operation that is objected to.

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[15] Lord v. DeWitt, 116 Fed. 713 (1902); see also Rogers v. Elliott, 146 Mass. 349, 15 N. E. 768 (1888); Coombs v. March, 7 Dist. & C. 791 (Pa. 1926); Powell v. Bentley, *supra* note 9; Gaunt v. Finney, 8 Ch. App. 8 (1872); Heath v. Mayor of Brighton, 98 L. T. 718 (1908). *Cf.* Harrison v. St. Mark's Church, 12 Phila. 259 (Pa. 1877).

[16] Froelicher v. Oswald Iron Works, 111 La. 705, 35 So. 821 (1903); Sardo v. James Russell Boiler Works, 241 Mass. 215, 135 N. E. 127 (1922); Marshall v. Holbrook, *supra* note 11; Beane v. H. K. Porter, Inc., *supra* note 11; Robinson v. Baugh, *supra* note 13; Eastcott v. Metal Craft Co., *supra* note 13; Elliotson v. Feetham, 2 Bing. 134 (N. C. 1835); Ereon v. Niagara Steel Finishing Co., 100 Misc. 619, 166 N. Y. Supp. 442 (1917); Shaw v. Queen City Forging Co., 7 Ohio N. P. 255 (1900); Dennis v. Eckhart, 3 Grant 390 (Pa. 1862); Collins v. Wayne Iron Works, *supra* note 13; Beuchel v. Streng, 63 PITTS. L. J. 393 (Pa. 1915); Ebur v. Alloy Metal Wire Co., *supra* note 14. *Cf.* Cremidas v. Fenton, 223 Mass. 249, 111 N. E. 855 (1916); Roy v. Chevrolet Car Co., *supra* note 12; Hauser v. Kraeuter & Co., *supra* note 12; Fish v. Dodge, *supra* note 8; Hafer v. Guyman, *supra* note 12; Austin v. Converse, *supra* note 12.

[17] Lohmuller v. Kirk, *supra* note 12; Wallace v. Auer, 10 Phila. 356 (Pa. 1875); Blomen v. Barstow Co., 35 R. I. 198, 85 Atl. 924 (1913).

[18] 22 W. N. C. 75, 13 Atl. 537 (Pa. 1888).

[19] Nailor v. Blakeslee, 167 Atl. 548 (Conn. 1933); McMorran v. Cleveland Cliff Iron Co., 253 Mich. 65, 234 N. W. 163 (1931); Reilley v. Curley, 75 N. J. Eq. 57, 71 Atl. 700 (1908); Friedman v. Keit, 113 N. J. Eq. 37 (1933); Krocker v. Westmoreland Planing Mill, *supra* note 9: Dillon v. Cortland Baking Co., 224 App. Div. 303, 230 N. Y. Supp. 289 (1928); Kennedy v. Frechette, 45 R. I. 399, 123 Atl. 146 (1924); Chadwick v. Toronto, 26 ONT. WEEKLY REP. 155 (1914); Bosworth-Smith v. Gwynnes, Ltd., 122 L. T. R. 15 (1920). *Cf.* Damadio v. Levinsohn, *supra* note 9; Butterfield v. Klaber, 52 How. Pr. 255 (N. Y. 1875); Knaub v. Meyer, 141 N. Y. Supp. 819 (Sup. Ct. 1913); Miranda v. Buffalo Gen. Elec. Co., 140 Misc. 267, 251 N. Y. Supp. 510 (1931); Haber v. Paramount Ice Co., 267 N. Y. Supp. 349 (App. Div. 1933); Coombs v. March, *supra* note 15; McCann v. Strang, 97 Wis. 551, 72 N. W. 1117 (1897); Heath v. Mayor of Brighton, *supra* note 15.

[20] Hustleton v. Park, 256 Pa. 255, 100 Atl. 798 (1917); Polsue & Alfieri, Ltd. v. Ruchmer [1907]. A. C. 121, *aff'g* [1906] 1 Ch. 234, 75 L. J. Ch. 79: Hey v. Seifert & Baime, 95 N. J. Eq. 502, 123 Atl. 106 (1923). *Cf.* McCaffrey's Appeal, 105 Pa. 253 (1884).

[21] Bickley v. Morgan Utilities Co., 173 Ark. 1038, 294 S. W. 38 (1927); Clay County Ice Co. v. Littlefield, 63 S. W. (2d) 530 (Ark. 1933); Mitchell v. Flynn Dairy Co., 172 Iowa 583, 154 N. W. 878 (1915); Crump v. Carnahan, 155 La. 648, 99 So. 493 (1924); Shea v. National Ice Cream Co., 280 Mass. 206, 182 N. E. 303 (1932); Kobielski v. Belle Isle East Side Creamery Co., 222 Mich. 656, 193 N. W. 214 (1923); O'Connor v. Jersey Creamery Co., 263 Mich. 86, 248 N. W. 557 (1933); Roukovina v. Island Farm Creamery Co., *supra* note 14; Hamilton v. Bates, 284 Pa. 513, 131 Atl. 369 (1925); Sturges v. Bridgman, *supra* note 14. *Cf.* Fanshawe v. London and Provincial Dairy Co., 4 T. L. R. 694 (1888); Crossett v. Standard Ice Mfg. Co., *supra* note 12.

[22] Episcopo v. Olivere, *supra* note 9; McPherson v. First Presbyterian Church, 120 Okla. 40, 248 Pac. 561 (1926); Nesbit v. Risenman, 298 Pa. 475, 148 Atl. 695 (1930); Scully v. Massey, 17 Dist. & C. 363 (Pa. 1932); Baker v. Moore, 311 Pa. 38, 166 Atl. 362 (1933). *Cf.* Sprout v. Levinson, 298 Pa. 400, 148 Atl. 511 (1930); Pierce v. Kelner, 304 Pa. 509, 156 Atl. 61 (1931); Franklin St. M. E. Church v. Crystal Oil & Gas Co., 309 Pa. 357, 163 Atl. 910 (1932). See Ruppin, *Public Garages as Nuisances* per se (1932) 81 U. OF PA. L. REV. 29.

Thus in *Kobielski v. Belle Isle East Side Creamery Co.*[23] the testimony showed that active work began shortly after midnight and continued until seven or eight in the morning, heavily loaded auto trucks and numerous milk wagons came and went, milk cans were thrown about and there was loud talking and some swearing at the restless horses. The complainants who were deprived of their sleep and unable to keep their tenants were held entitled to an injunction. Indeed, loud and profane talk, boisterous conduct and continuous unnecessary noise are forms of disturbance easily avoided and have frequently been checked by injunction or indictment.[24] The blowing of a factory whistle in the early morning hours has been held a nuisance.[25] So the noise of airplanes has been considered as one ground of annoyance in proceedings to enjoin the use of a tract of land as an airport.[26] As respects one point, there seems to be a general agreement that noises which would not under the circumstances be held a nuisance in the daytime may well be declared a nuisance if made at night. The occupants of dwellings and apartments are entitled to protection from disturbance during ordinary sleeping hours.[27] In some instances a less stringent rule has been applied to temporary noises during building operations.[28] Even so, damages have been awarded in Massachusetts against a building contractor with respect to unnecessary noises by his workmen in the early morning.[29] On the whole, and without any change in the language of the courts, there can be detected a tendency to require from industry an increased regard for the comfort of the surrounding community. Improved building construction, more skillful engineering, make this possible without imposing too heavy a burden on essential activities.

A few cases concern hospitals. Although conducted as a gainful occupation, the hospital is charitable in spirit and essential to the practice of modern medicine. Nevertheless, a hospital must be conducted with due regard to the comfort and health of others. Even when as a charitable institution it may not be subject to an action at law, it may still be enjoined from maintaining a nuisance.[30] A court of equity may require a hospital so to arrange its internal construction as not to distress its neighbors by exposing them to the groans and moans of the operating room.[31] So, in a recent New York case, a private hospital for alcoholics and drug addicts was enjoined from disturbing the neighborhood by failing to control the cries and screams of the patients.[32]

Whether the keeping and breeding of animals is regarded as an industry or a sport, the obviously proper place for it, as regards both the creatures themselves and the neighbors, is in the great open spaces made familiar by the motion pictures. But one may be of a sociable disposition, and a lover not only of pets but of his fellow men. It is also an advantage to be close to one's market, even at the risk of annoying some, who under no circumstances could be conceived of as customers. The barking of dogs has frequently led to litigation. The dog is a noisy animal and is valued on that account.

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[23] *Supra* note 21; see cases cited *supra* note 21.

[24] Birmingham News Co. v. Little, 226 Ala. 642, 148 So. 398 (1933) (newspaper); Commonwealth v. Oaks, 113 Mass. 8 (1873); Friedman v. Keil, *supra* note 19 (bakery); Barnard v. Finkbeiner, 162 App. Div. 319, 147 N. Y. Supp. 514 (1914) (apartment house); People v. Borden's Condensed Milk Co., 165 App. Div. 711, 151 N. Y. Supp. 547 (1915); People v. Weeks, 172 App. Div. 117, 158 N. Y. Supp. 39 (1916); Attorney-General v. Corke, 102 L. J. Ch. 30 (1933); Innes v. Newman, [1894] 2 Q. B. 232; Bartlett v. Marshall, 60 J. P. 104 (1896) (newsdealer); Vanderpant v. Mayfair Hotel Co. [1930], 1 Ch. 138 (hotel). *Cf.* Leonard v. Hotel Majestic, 17 Misc. 229, 40 N. Y. Supp. 1044 (1896); Appeal of Penrose, 140 Pa. 45, 21 Atl. 364 (1891).

[25] Hill v. McBurney, 112 Ga. 788, 38 S. E. 42 (1900); Mackenzie v. Pauli Co., 207 Mich. 456, 174 N. W. 161 (1919). *Contra:* Redd v. Edna Cottton Mills, 136 N. C. 342, 48 S. E. 761 (1904). See also Daughterty v. Southern C. O. Co., 138 Ark. 329, 211 S. W. 179 (1919).

[26] Sweetland v. Curtis Airports Corp., 55 F. (2d) 201 (C. C. A. 6th, 1932). See also People v. Smith, 119 Misc. 294, 196 N. Y. Supp. 241 (1922), *rev'd,* 206 App. Div. 642; Gay v. Taylor, 19 Dist. & C. 31 (Pa. 1933).

[27] Wheat Culvert Co., Inc. v. Jenkins, 246 Ky. 319, 55 S. W. (2d) 4 (1932); Deevers v. Land, 220 Mo. App. 50, 285 S. W. 746 (1926); Friedman v. Keil, *supra* note 19; Seligman v. Victor Talking M. Co., 71 N. J. Eq. 697, 63 Atl. 1093 (1906); Shea v. National Ice Cream Co., Inc., *supra* note 21; Andrews v. Perry, 127 Misc. 320, 216 N. Y. Supp. 537 (1926); Yocum v. Hotel St. George, 18 Abb. N. C. 340 (N. Y. 1887); Collins v. Wayne Iron Works, *supra* note 13; Robin v. Kolb, 88 Pa. Super. 80 (1926); Stetter v. Reliable Silk Mfg. Co., 42 Lanc. L. Rev. 369 (Pa. 1930); De Keyser's Royal Hotel, Ltd. v. Spicer Bros., Ltd., 30 T. L. R. 257 (1914). Relief was refused in Monlezun v. Jahncke Dry-Docks, Inc., *supra* note 12. The disturbance of night workers by daytime noises does not seem to justify interference. Attorney-General v. Doremus, *supra* note 4.

[28] Phelps v. Mayor, [1916] 2 Ch. 255; Clark v. Lloyds Bank, Ltd., 103 L. T. 211 (1910); Lord v. DeWitt, *supra* note 15.

[29] Nugent v. Melville Shoe Co., *supra* note 14.

[30] Herr v. Central Ky. Lunatic Asylum, 97 Ky. 458, 30 S. W. 971 (1895). See generally Notes (1919) 4 A. L. R. 995, (1922) 18 A. L. R. 119.

[31] Kestner v. Homeopathic M. & S. Hospital, 22 Dist. R. 793 (Pa. 1911); Deaconess Home v. Bontjes, 207 Ill. 553, 69 N. E. 748 (1904), *aff'g* 104 Ill. App. 484 (1902).

[32] Keenly v. McCarty, 137 Misc. 524, 244 N. Y. Supp. 63 (1930). *Cf.* Heaton v. Packer, 131 App. Div. 812, 116 N. Y. Supp. 46 (1909).

As put by the judge in the lower court in a Colorado case: "To some ears the barking of a dog, especially on the person's own premises, is a sound that is pleasing and one which tends to make him feel secure." But the Supreme Court in that case took a less indulgent view of the defendant's conduct in maintaining in the suburbs of a city a kennel and dog hospital with accommodations for ninety-three dogs which howled and barked day and night continuously, disturbing and keeping awake the plaintiff, his wife and children, rendering them nervous and irritable and depriving them of the proper enjoyment of their home, and reversed the judgment for defendant with directions to grant an injunction unless the nuisance was discontinued.[33] Indeed there are circumstances under which the barking of a single dog may be a nuisance.[34] But dogs are far from being the only animals whose noise has called for judicial intervention. In *Singer* v. *James*[35] the plaintiff, whose residence was a mile and a half from Baltimore, was held entitled to an injunction restraining the defendant from keeping such a great number of fowls, hogs and dogs that their noise deprived the plaintiff and his family of the comfortable enjoyment of their dwelling house. Constant noise from the stamping and kicking of horses in an adjoining stable has resulted in an injunction.[36] The bleating of calves day and night at a slaughter house to the annoyance of an adjoining ower has been suppressed;[37] a city ordinance forbidding the keeping of goats within a fixed distance of a dwelling has been held reasonable.[38]

On the other hand, the lessee of a hotel in a borough was unsuccessful in restraining an adjoining owner from keeping game cocks and chickens that disturbed his guests by loud crowing from one to five in the morning. Said the court, with a martyr's resignation: "There are numberless noises and inconveniences which are not conductive to perfect rest, but all these are the music of the night, and while silently bearing with them, we must at times close our windows and keep out or deaden the disturbing sounds, if we would hope for partial quietude."[39] In one case, the noisy presence of crickets in a leased apartment was set up as a constructive eviction, unsuccessfully it is true;[40] but the proposition is an indication of the effect that seemingly slight disturbances may have upon irritated nerves. In the animal noise cases the locality of the disturbance is no doubt an important factor in determining the question of nuisance; but, as in other types of annoyance, it is not necessarily the deciding factor. In several of the most important cases cited above, the contending parties resided in small towns or city suburbs.

Where the disturbing sounds have their origin in enterprises connected with public entertainment or sport, one would expect that a more exacting standard of conduct would be imposed than for vital economic services. Such is the view of the New Jersey Court of Chancery: ". . . in considering whether a noise amounts to a nuisance," says Vice-Chancellor Pitney, "the question whether or not it is made for a necessary or useful purpose is always taken into consideration."[41]

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[33] Krebs v. Hermann, 90 Colo. 61, 6 P. (2d) 907 (1931). Note (1932) 79 A. L. R. 1054, 1066. Accord: Kansas v. Stillwell, 114 Kan. 808, 220 Pac. 1058 (1923); Chambers v. Walker, 57 PITTS. L. J. 210 (Pa. 1909); Herring v. Wilton, 106 Va. 171, 55 S. E. 546 (1906). *Cf.* Street v. Tugwell (1800), 2 SELW. N. P. (9th ed. 1838) 1138; Heylman v. Dist. of Columbia, 27 App. D. C. 563 (1906).

[34] Force v. Dahn, 10 N. J. L. J. 252 (1887); Hechelman v. Kindt, 22 Dist. R. 791 (Pa. 1911). But see Woolf v. Chalker, 31 Conn. 121 (1862); Seegmueller v. Pahner, 9 Ohio C. C. (N. S.) 333 (1907). As to shooting dogs *cf.* Hubbard v. Preston, 90 Mich. 221, 51 N. W. 209 (1892); Brill v. Flagler, 23 Wend. 354 (N. Y. 1840), with Jacquay v. Hartzell, 1 Ind. App. 500 (1891); Bowers v. Horen, 93 Mich. 420, 53 N. W. 535 (1892). See also Strong v. Georgia Ry. & E. Co., 118 Ga. 515, 45 S. E. 366 (1903), for kind words as to dogs.

[35] 130 Md. 382, 100 Atl. 642 (1917).

[36] Broder v. Saillard, 2 Ch. D. 692 (1876); Ball v. Ray, L. R. 8 Ch. App. 467 (1873). See action on case Dargan v. Waddell, 9 Tred. 244 (N. C. 1848). *Cf.* Haughton v. Kendick, 285 Pa. 223, 132 Atl. 166 (1926).

[37] Bishop v. Banks, 33 Conn. 118 (1865).

[38] *In re* Matthews, 191 Cal. 35, 214 Pac. 981 (1923); see 58 Cal. App. 649 (1922). *Cf.* *Ex parte* Von Koenneritz, 97 Tex. Cr. R. 294, 261 S.W. 570 (1924).

[39] Hillegas v. Reinhart, 20 LANC. L. REV. 137, 140 (Pa. 1903). See also Higgins v. Decarah Produce Co., 214 Iowa 276, 242 N.W. 109, 81 A. L. R. 1199 (1932); Hunt v. W. H. Cook, Ltd., (1922) 66 SOL. J. 557.

[40] Ben Har Holding Corp. v. Fox, 147 Misc. 300, 263 N. Y. Supp. 695 (1933). Unfortunately the tenant was a tuba player. "It is singular," said the court, "that a musician should complain about another musician." *Id.* at 307, 263 N. Y. Supp. at 702.

So, in a suit to restrain the operation of a roller skating rink, when it was suggested that louder noises were made by passing trains, trolley cars and automobiles, the court pointedly observed that these were necessities, while the present case related to a private business in no sense a public necessity.[42] But as a rule, the cases do not avowedly stress the relative importance of the source of disturbance, whatever it may be, where substantial injury is inflicted upon the complaining party. This may reflect the modern attitude toward recreation, as compared with the older tendency to look with suspicion on any sort of entertainment for the public outside of military exercises and traditional festivals. Some forms of amusement have long been under the ban of the law. The gaming house and the bawdy house are nuisances *per se*, although conducted with an outward appearance of decorum.[43] At common law a stage for rope dancers and a bowling alley were indictable as common nuisances. Rope dancers have left the highways for vaudeville, and as for bowling alleys, they are hardly any longer to be regarded as evil haunts "from their tendency to withdraw the young and inconsiderate from any useful employment".[44] Some early American decisions support the old and stern doctrine;[45] but the prevailing opinion today is that a bowling alley is not a nuisance *per se*, although like other noisy forms of recreation, it may in fact be held a nuisance on account of its location or the manner in which it is conducted.[46]

The disturbance of residents by organized sports or amusements may result either from sounds originating in the activities themselves, or from the almost inevitable noise of the attending throngs. In *Walker v. Brewster*[47] a property owner was enjoined from permitting his grounds to be used for what were described as monster fetes, with displays of fireworks. There was music by bands and dancing and, of course, crowds of spectators. The court pointed out the difference between private entertainment and the business of giving entertainments and collecting crowds. The case is the precursor of many others seeking to restrain the noisy operation of various types of amusement parks and picnic grounds.[48] "When people came to be amused [in swings and roundabouts]," observed the court in one case, "one's ordinary experience told one they would shout; it was a necessary consequence of their mode of enjoying themselves. There was nothing improper in it, but it could not be permitted to interfere with peoples' comfort."[49] Roller coasters, with their combination of noisy apparatus and excitable riders, have been a frequent source of complaint.[50] Athletic clubs have been restrained from disturbing a residential neighborhood by boxing contests at night that drew crowds and caused noise and confusion.[51] On the other hand the court need not anticipate that nuisance will result from the mere fact that a number of people will assemble at a particular spot, as in the case of an open air tabernacle[52] or auditorium.[53]

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[41] Gilbough v. West Side Amusement Co., 64 N. J. Eq. 27, 53 Atl. 289 (1903), quoted in Riffey v. Rush, 51 N. D. 188, 199 N. W. 523 (1924).

[42] First M. E. Church v. Cape May G. & C. Co., 73 N. J. Eq. 257, 67 Atl. 613 (1907). See other rink cases: Manos v. City of Seattle, 24 P. (2d) 91 (Wash. 1933); Snyder v. Cabell, 29 W. Va. 48, 1 S. E. 241 (1886); Churchwardens of the Church of St. Margaret v. Stephens, 29 Ont. L. R. 180 (1898).

[43] Barnett v. Tedescki, 154 Ala. 474, 45 So. 904 (1908); De Forest v. United States, 11 App. D. C. 458 (1897); Commonwealth v. Godall, 165 Mass. 588, 43 N. E. 520 (1896); People v. Elmore, 256 N. Y. 489, 177 N. E. 14 (1931); Commonwealth v. Ciccone, 85 Pa. Super. 316 (1925). Drawing together great numbers of disorderly persons, to the inconvenience of the neighborhood, a practice referred to by Hawkins in 1 PLEAS OF THE CROWN (1716) 198, has, through the reluctant efforts of the police urged on by reformers, almost disappeared. Only an occasional road house preserves the manners of ruder days. Roulette is not as noisy as a radio and a more sophisticated younger generation would rather live next door to a strumpet than a trumpet. Still the morals must be preserved of those who cannot get away to the Riviera.

[44] State v. Haines, 30 Me. 65 (1849). See Jacob Hall's Case, 1 Mod. 76 (1671); 1 HAWKINS, *op. cit. supra* note 43, at 693.

[45] Bloomhuff v. State, 8 Blackf. 205 (Ind. 1846); State v. Haines, *supra* note 44; Tanner v. Trustees of Albion, 5 Hill 121 (N. Y. 1843); Updike v. Campbell, 4 E. D. Smith 570 (N. Y. 1855).

[46] City of Shreveport v. Liederkrantz Soc., 130 La. 802, 58 So. 578, 40 L. R. A. (N. S.) 75 (1912); Hamilton Corp. v. Julian, 130 Md. 597, 101 Atl. 558 (1917); State v. Hall, 32 N. J. L. 158 (1867); Peragallo v. Luner, 99 N. J. Eq. 726, 133 Atl. 543 (1926); Pape v. Pratt Inst., 127 App. Div. 147, 111 N. Y. Supp. 354 (1908); Briggs v. Vottler, 4 W. N. C. 272 (Pa. 1877); Morey v. Black, 21 Montg. Co. 102 (Pa. 1904); Spano v. Duke, 23 Del. Co. 513 (Pa. 1931). Happily for bench and bar golf is not a nuisance *per se*. Gleason v. Hillcrest Golf Course, Inc., 148 Misc. 246, 265 N. Y. Supp. 886 (1933).

[47] L. R. 5 Eq. 25 (1867).

[48] Phelps v. Winch, 309 Ill. 158, 140 N. E. 847, 28 A. L. R. 1169 (1923); Off v. Exposition Coaster, Inc., 336 Ill. 100, 124 N. E. 472 (1929); Palestine B. Assn. v. Minor, 27 Ky. L. R. 781, 86 S. W. 695 (1905); Commonwealth v. Cincinnati, *etc.* R. R., 139 Ky. 429, 112 S. W. 613 (1908); Edmunds v. Duff, 280 Pa. 355 (1924); Turtle v. Fitchett, 156 Wash. 328, 287 Pac. 7 (1930); Inchbald v. Robinson, 4 Ch. App. 388 (1869) (circus); Becker v. Earls' Court, Ltd., 56 SOL. J. 73 (1911); Bedford v. Leeds Corp., 77 J. P. 430 (1913). *Cf.*, injunction refused: Burroughs v. City of Dallas, 276 Fed. 812 (C. C. A. 5th, 1921); Pfingst v. Senn, 94 Ky. 556, 23 S. W. 358 (1893); Iford v. Nickel, 1 S. W. (2d) 751 (Tex. Civ. App. 1928); Hornsby v. Crystal Beach Park, 41 S. W. (2d) 82 (Tex. Civ. App. 1931); see Village of Des Plaines v. Poyer, 123 Ill. 348, 14 N. E. 677 (1888); Germaine v. London Exhibitions, Ltd., 75 L. T. 101 (1896).

In an Irish case race meeting on Sunday were enjoined where the shouting and cheering of the crowds and the cries of the bookmakers disturbed the quiet enjoyment of suburban homes and interfered with church services.[54] And in this country a similar principle has been applied, although not uniformly, to Sunday baseball.[55] The game, however, is not a nuisance *per se* and under ordinary circumstances injury must be shown.[56] So also a dance hall is not a nuisance *per se*, although it may become a nuisance from the manner in which it is conducted and from the behavior of the persons assembled in and around it.[57] "Among the noises," it has been said, "which, if they do not cause substantial discomfort, residents in large industrial cities may have to put up with, is a certain amount of the noise which accompanies and is incident to the reasonable recreation of a crowded population. In the fashionable quarter of a city a similar discomfort is experienced at certain seasons, and, within due limits, may have to be submitted to."[58] The miniature golf course, which came and went so quickly, has left reminders that even so mild a form of entertainment may in its operation become objectionable to nearby residents.[59] An instructive case is *Ackers v. Marsh*,[60] where the gentle game of croquet came under the scrutiny of the court. The bill was to restrain the playing of this game on a vacant lot opposite the complainants' residence in the city of Washington during the evening, not later than 11 P. M. A decree granting an injunction was reversed on appeal in a well considered opinion which found the complainants unduly sensitive.

An approach to the cases concerned with music is complicated by the embarrassing question, what is music? Perhaps it is best to avoid the always delicate problem of art as did Mr. Justice Kekewich. Whether classical music was more distracting than works of a lower class, he could not say.[61] Lord Selbourne has summed up the comomn sense view: "A nuisance by noise (supposing malice to be out of question) is emphatically a question of degree. If my neighbor builds a house against a party wall, next to my own, and I hear through the wall more than is agreeable to me of the sounds from his nursery or his music-room, it does not follow (even if I am nervously sensitive or in infirm health) that I can bring an action or obtain an injunction. Such things to offend against the law must be done in a manner which, beyond fair controversy, ought to be regarded as exceptive and unreasonable."[62] A wilful and malicious disturbance by loud noises is actionable, as it should be.[63] But that does not mean that popular songs may not be sung in a private residence or club, although unappreciated by the listeners, in the absence of malicious or disorderly conduct.[64] The giving of music lessons by a teacher of music even when supplemented by practice on such instruments as the piano and violin and singing, has been held not such an annoyance as to entitle an adjoining resident to an injunction.[65] But in one instance an injunction was granted to restrain vocal music on the premises of a manufacturer and dealer in musical instruments which disturbed an adjoining business.[66]

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[49] Winter v. Baker. 3 T. L. R. 569, 570 (1887). See also Lambton v. Mellish [1894], 3 Ch. D. 163.

[50] Schlueter v. Billingheimer, 9 Ohio Dec. (Reprint) 513 (1885); Edmunds v. Duff, *supra* note 48; see cases cited *supra* note 48, and Note (1924) 33 A. L. R. 725. A merry-go-round was enjoined in Town of Davis v. Davis, 40 W. Va. 464, 21 S. E. 906 (1895). In Attorney-General v. Doremus, *supra* note 4, an injunction to restrain trap shooting was refused.

[51] Russell v. Nostrand Athletic Club, Inc., 212 App. Div. 543, 209 N. Y. Supp. 76 (1925); Bellamy v. Wells, 60 L. J. Ch. 156 (1891).

[52] Murphy v. Cupp, 182 Ark. 334, 31 S. W. (2d) 396 (1930).

[53] Sheets v. Armstrong, 307 Pa. 385, 161 Atl. 359 (1932). See also Jones v. Little Rock Boys' Club, 182 Ark. 1050, 34 S. W. (2d) 222 (1931) (recreation center); Briggs v. City of Grand Rapids, 261 Mich. 11, 245 N. W. 555 (1932) (football field); City of Lynchburg v. Peters, 145 Va. 1, 133 S. E. 674 (1926) (stadium).

[54] Dewar v. City & Suburban Racecourse Co. [1899], 1 Ir. R. 345.

[55] Gilbough v. West Side Amusement Co., *supra* note 41; Seastream v. New Jersey Exhibition Co., 67 N. J. Eq. 178, 58 Atl. 532 (1904) (injunction granted); McMillan v. Kuehnle, 78 N. J. Eq. 251, 78 Atl. 185 (1910) (injunction refused). Where a nuisance occurs it makes no difference that the enjoyment of the property interfered with is religious and devotional. Churchwardens of the Church of St. Margaret v. Stephens, *supra* note 42.

[56] Alexander v. Tebeau, 24 Ky. L. R. 1305, 71 S. W. 427 (1903); Cronin v. Bloemecke, 58 N. J. Eq. 313, 43 Atl. 605 (1899); Riffey v. Rush, *supra* note 41; Peden v. Furman University, 155 S. C. 1, 151 S. E. 907 (1930); Royse Ind. Sch. Dist. v. Reinhardt, 159 S. W. 1010 (Tex. Civ. App. 1913).

[57] McPheeters v. McMahon, 21 P. (2d) 606 (Cal. App. 1933); Whitcomb v. Vigeant, 240 Mass. 359, 134 N. E. 241, 19 A. L. R. 1439 (1922); Thoenebe v. Mosby, 257 Pa. 1, 101 Atl. 98 (1917); Truehart v. Parker, 257 S. W. 640 (Tex. Civ. App. 1923); Cain v. Truehart, 12 S. W. (2d) 239 (Tex. Civ. App. 1928); Tarr v. Hopewell Community Club, 153 Wash. 214, 279 Pac. 594 (1929). *Cf.* Commonwealth v. Cardoze, 119 Mass. 210 (1875); Linden v. Fischer, 191 N. W. 901 (Minn. 1923); People v. Rubenfeld, 254 N. Y. 245, 172 N. Y. Supp. 485 (1930).

[58] New Imperial and Windsor Hotel Co. v. Johnson [1912], 1 Ir. R. 327, 336.

[59] Central Trust and Savings Co. v. Mencke, 14 Dist. & C. 115 (Pa. 1930); Gottschall v. McIlhenny, 36 Dauph. Co. 366 (Pa. 1931). *Cf.* Drennen v. Mason, 133 So. 689 (Ala. 1931); Rickard v. Feinstone, 14 Dist. & C. 114 (Pa. 1930) (injunction to restrain construction refused).

[60] 19 App. D. C. 28 (1901).

[61] Motion v. Mills, 13 T. L. R. 427 (1897).

The Salvation Army has not come off as well as the teachers, owing to municipal regulation of street music,[67] although in one case it was said that the use of the streets contemplates not quiet and repose but the noise and bustle incident to the transaction of business and the harmless pleasures and devotions of the people.[68] Whether bells may be classed with musical instruments is a question upon which opinions may differ. At least they have tonality, ritual significance, and in some cases practical value, as on fire engines and alarm clocks. The leading case is *Soltau v. DeHeld*.[69] There a chime of bells, that had been installed on the roof of a house converted into a chapel, was rung five times on weekdays and more frequently on Sundays, to the disturbance and annoyance of the complainant and his family. An injunction was granted, and the same principle has been applied in other cases of chimes and church bells as well as bells used for secular purposes where the ringing has been unreasonable and unusual.[70] In *Cluney v. Lee Wai*[71] an injunction was granted to restrain the use of objectionable musical instruments in a Chinese theatre during hours that interferred with sleep. The orchestra included gongs, drums and wind instruments, and the music was described as harsh, strident and discordant. This would rule out most contemporary compositions; but such works are seldom heard except by those who pay for the privilege in sanctuaries devoted to the art.

Not the music itself but the mode of production is the true source of complaint in numerous cases where mechanical means are depended on for the production of a continuous volume of tuneful sounds as a means of enlivening pleasures that might otherwise prove monotonous, and, perhaps more often, as a method of attracting customers to the scene of revelry. The continual operation of steam organs and other loud instruments to the discomfort of nearby residents has frequently been enjoined.[72] In *Winter* v. *Baker*[73] it was said that the organ was a good organ but its goodness was in its loudness. In *Lambton* v. *Mellish*[74] the organ could be heard a mile. That is much too far. The ingenuity of modern advertising has its trials as well as its seductions. *Stodder* v. *Rosen Talking Machine Co.*[75] is a leading case. The defendant placed in his doorway a talking machine operated by an electric motor which was played from 10 A.M. until 5 P.M. or later, the records consisting of every variety, singing, speaking and instrumental. The continuous and monotonous playing, which was found to be a substantial addition to the other noises of the street, injuriously affected the plaintiffs and their employees, in their place of business immediately opposite, by gradual wear on their nervous systems and by making it difficult for them to concentrate on their work.

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[62] Gaunt v. Finney, L. R. 8 Ch. App. 8, 12 (1872). See also Lord Justice Mellish in Ball v. Ray, *supra* note 36, "not . . . like the noise of a pianoforte . . . or . . . children in their nursery, which are noises we must reasonably expect."

[63] Shellabarger v. Morris, 115 Mo. App. 566 (1905). "A great noise in the night-time, made by the human voice or by blowing a trumpet, is a nuisance to those near whom it is made." Bankus v. State, 4 Ind. 114, 116 (1853); Rex v. Smith, 2 Strange 704 (1725). But *cf.* Owen v. Herman, 1 W. & S. 348 (Pa. 1841) (disturbance of worshipper in church by loud singing not actionable).

[64] Miller v. Jersey Coasts Resorts Corp., 98 N. J. Eq. 289, 130 Atl. 824 (1925).

[65] Tonnelle v. Hayes, 118 Misc. 339, 194 N. Y. Supp. 181 (1922); Christie v. Davey [1893]. 1 Ch. 316; Pope v. Peate, 7 Ont. L. R. 207 (1904).

[66] Motion v. Mills, *supra* note 61. The plaintiffs were, among other things, auctioneers.

[67] Wilkesbarre v. Garebed, 9 Kulp 273 (Pa. 1898); Commonwealth v. Krubeck, 8 Dist. R. 521 (Pa. 1899); Anonymous, 77 J. P. 256 (1913).

[68] *In re* Gribben, 5 Okla. 379, 47 Pac. 1074 (1897). See also Regina v. Nunn, 10 Ont. Pr. 395 (1884).

[69] *Supra* note 2.

[70] Appeal of St. Mark's Church, 34 LEG. INT. 222 (Pa. 1877), *aff'g* Harrison v. St. Mark's Church, *supra* note 15, and see the same case in 17 Phila. 87 (Pa. 1883). See further, Davis v. Sawyer, 133 Mass. 289 (1882); Leete v. Pilgrim Congregational Soc., 14 Mo. App. 590 (1883); Terhune v. Methodist Episcopal Church, 87 N. J. Eq. 195, 100 Atl. 342 (1917); People v. Hess, 110 Misc. 76, 179 N. Y. Supp. 734 (1920). *Cf* Hardman v. Holberton, W. N., Dec. 8, 1866, at 379 (injunction refused nervous plaintiff who objected to clock chiming quarter hours); Rogers v. Elliott, 146 Mass. 349, 15 N. E. 768 (1888) (plaintiff thrown into convulsions by loud noises).

[71] 10 Hawaii 319 (1896).

An injunction was granted restraining the defendants from playing in the entrance of their store any records on a talking machine in such a manner as to cause the noise produced to be "appreciably audible or heard" in any part of the respective places of business of the plaintiffs. Damages were also awarded. Upon a subsequent violation of the injunction the defendants were fined for contempt.[76] In a recent Texas case[77] an injunction was sought against the defendant who operated a root beer stand in a manner considered objectionable by the plaintiff, whose home was on the opposite side of the street. Among various nuisances it was alleged that a radio was maintained at all hours of the day and night. The court below, among other things, perpetually enjoined the defendant from using a radio, and this was one of the errors for which judgment was reversed. "Clearly," said the court, "a radio is not a nuisance *per se*. The record shows that practically every residence and each of the other places of business surrounding appellant's root beer stand is equipped with or has a radio. We do not hold that a radio cannot be so operated that it would not become a nuisance or that a court could not require a party to so operate his radio that it would not be a nuisance. The fact, however, that the radio was being operated as a nuisance would not authorize the trial court to absolutely prohibit its use." That cases dealing with the noise of loudspeakers are few may be attributed in part to the novelty of these instruments and the rapid progress of their development, and in part to a tendency to correct such abuses as may occur through penalties imposed by municipal ordinances.[78]

In this too brief survey of the decisions bearing on nuisances resulting from excessive noises of various sorts, many interesting judgments that deserve extended comment are relegated to the notes, as well as other cases that invite criticism. Enough has been said to show the general trend of authority. Courts of equity are not so slow as they once were to interfere for the prevention of tortious conduct. Criticism of the law's delay has had its effect. In the nuisance cases generally, the fatalism that once found discomfort the ordinary mortal lot, is giving place to an insistence that engineering skill shall be applied to reduce to the utmost the annoyances incidental to modern life. Legal standards of what should be regarded as ordinary and reasonable comfort improve, as the standard of living rises, and life becomes more civilized. It is curious that until very recently no scientific effort was made to determine the incidence of noise and its effect on health. An eminent judge has said: "That the subjection of a human being to a continued hearing of loud noises tends to shorten life is, I think, beyond all doubt."[79] But a standard work of reference says: "The usual assumption that noise is harmful to man is by no means proved. Noise is known to affect the human heartbeat as well as the rate at which heat energy is set free in the human body, but the details of these effects have not been studied. Most individuals accustom themselves to living and working in noisy surroundings and only nervous individuals who fail to make this adjustment suffer harmful effects."[80] This would seem an understatement, but such problems are now the subject of inquiry in various laboratories of psychology.

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[72] Feeney v. Bartoldo, 30 Atl. 1101 (N. J. Eq. 1895) (piano); Osthaus v. Robinson, 12 Dist. R. 25 (Pa. 1902); Grantham v. Gibson, 41 Wash. 125, 83 Pac. 14 (1905) (orchestrion); Town of Davis v. Davis, *supra* note 50 (band); Winter v. Baker, 3 T. L. R. 569 (1887); Spruzen v. Dossett, 12 T. L. R. 246 (1896); Bedford v. Leeds Corporation, *supra* note 48; Lambton v. Mellish, *supra* note 49 (organs).

[73] *Supra* note 72.

[74] *Supra* note 49.

[75] 241 Mass. 245, 135 N. E. 251 (1922).

[76] Stodder v. Rosen Talking Machine Co., 247 Mass. 60, 141 N. E. 569 (1923).

[77] Weber v. Mann, 42 S. W. (2d) 492 (Tex. Civ. App. 1931).

[78] DAVIS, RADIO LAW (1930) Pt. 1. c. 4.

[79] Pitney, V. C., in Gilbough v. West Side Amusement Co., *supra* note 41. Quoted with approval by Farmer, C. J., in Phelps v. Winch, *supra* note 48. In the latter case "The music was furnished by four college boys with a piano, saxophone, banjo and drum, and was the character of music suited to present-day methods of dancing, called 'jazz' music". *Id.* at 161, 140 N. E. at 848.

Recent medical opinion holds that the effect of noise on the nervous system is a constant drain on nervous energy leading to neurasthenia and breakdown. Fortunately, one community has made a thorough effort to investigate the problem, and the report of the commission appointed by the Commissioner of Health to study noise in New York City and to develop means to abate it is a document deserving the careful attention of all who are interested in municipal welfare.[81] Scientific noise measurements were taken in many parts of the city and questionnaires were furnished to persons who wished to take part in the survey. Traffic, radios, collections and deliveries, whistles and bells, construction and vocal disturbances all had their part, and while it is not possible to eliminate many of the noises of a busy city, they can be considerably reduced by better management where sound is inevitable, and discouraged when wholly unnecessary by municipal ordinance, as in the case of radios and sound devices used for advertising. The problem of the privately owned radio with loud speaker is concededly different. The radio is a new toy, an escape from boredom; youth beats time with its foot, and the lonely woman hears a man's voice. But like all new toys it is used at first with too much abandon, as some may remember was the case with the automobile in the days of the "scorcher".

Just as in the case of the barking dog and the noisy party, the annoyance is usually too petty for formal and expensive proceedings in equity, and ought, in all reason, to be settled by mutual concession and neighborly good will. This perhaps may be difficut where apartment house faces apartment house, each with its concealed battery of horns belching trite songs and oleaginous sales talks. But if selfish and obstinate persons insist on disturbing the neighborhood, the burden of equity proceedings ought not to be imposed on the injured residents, but the nuisance should be dealt with by municipal ordinance and a small fine, as has been found the only practical method of coping with violations of traffic rules. Much of this noise is the result of mere thoughtlessness, and the broadcasting stations by occasionally advising their patrons to turn their radios down low in the late evening, could do their part in retaining popular good will for an industry now enjoying the advantages of novelty, but bound sooner or later to come in for its share of regulation. All disturbing noises are not city noises by any means. In the deep country a few owls can give a pretty fair imitation of a radio concert and the early barnyard noises rival those of the ash collectors and other harbingers of dawn. Exceptionally nervous persons, or those whose refinement exceeds the standards of "the American people in the present state of enlightenment", as the Washington court put it, must seek refuge in sound proof rooms, if they can afford them, or take their chances of the padded cell. Indeed, air and sound conditioned houses may be the next luxury, when luxury is resumed, to the profit of our inventors and engineers, who, having devoted one century to creating pandemonium, may spend the next century in abating it.

CITY OF JACKSONVILLE v. SCHUMANN

Cite as, Fla., 167 So.2d 95

CITY OF JACKSONVILLE, a municipal corporation under the laws of Florida, APPELLANT, *v.* GEORGE SCHUMANN ET UX., ET AL., APPELLEES No. F–297.

(District Court of Appeal of Florida, First District, Aug. 18, 1964)
Rehearing Denied Sept. 18, 1964.

Inverse condemnation action against city. The Circuit Court for Duval County, Charles A. Luckie, J., entered order denying motions to dismiss the complaint for insufficiency and to strike certain portions thereof, and city appealed. The District Court of Appeal, Carroll, Donald K., Acting C. J., held that if jet aircraft using airport operated by city flew at altitudes less than 500 feet above owners' adjacent property and caused terrific and overwhelming, vibrations, concussions, and sound waves while advancing engines to near maximum power on warm-up pads and taxiing strips and caused exhaust fumes, fuel gases, and heavy black smoke to be transmitted against the adjacent properties, those property owners were entitled to recover from city on theory of inverse condemnation.

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[80] 16 ENCYCLOPAEDIA BRITANNICA (14th ed.) 480, tit., Noise and its Control.
[81] CITY NOISE (New York, 1930) Report of the Noise Abatement Commission.

Affirmed.

1. EMINENT DOMAIN ⚷266

"Inverse condemnation" is the popular description of a cause of action against a governmental defendant to recover value of property taken in fact by the defendant even though no formal exercise of power of eminent domain has been attempted.

2. EMINENT DOMAIN ⚷266

If jet aircraft using airport operated by city flew at altitudes less than 500 feet above owners' adjacent property and caused terrific and overwhelming vibrations, concussions, and sound waves while advancing engines to near maximum power on warmup pads and taxiing strips and caused exhaust fumes, fuel gases, and heavy black smoke to be transmitted against the adjacent properties, those property owners were entitled to recover from city on theory of inverse condemnation. U.S.C.A.Const. Amend. 5; F.S.A.Const. Declaration of Rights, §§ 4, 12; F.S.A.Const. art. 16, § 29.

3. EMINENT DOMAIN ⚷2(1)

Continuing trespass or nuisance may ripen into a "taking" of property within constitutional provisions prohibiting taking of property without payment of just compensation. U.S.C.A.Const. Amend. 5; F.S.A.Const. Declaration of Rights, § 12; F.S.A.Const. art. 16, § 29.

See publication Words and Phrases for other judicial constructions and definitions.

4. EMINENT DOMAIN ⚷293(1)

Allegations that as direct and proximate result of increased operation of jet planes from city's airport owners of nearby property had been deprived of the free and unmolested use and quiet enjoyment of their properties and that city had condemned those properties without just compensation or due process were relevant and material to cause of action of owners on theory of inverse condemnation.

William M. Madison; Claude L. Mullis and Joe R. Young, Jr., Jacksonville, for appellant.

Duss, Butler & Nelson, Jacksonville, for appellees.

Carroll, Donald K., Acting Chief Judge.

The defendant city in an action for "inverse condemnation" has filed this interlocutory appeal from an order entered by the Circuit Court for Duval County, denying its motions to dismiss and strike addressed to the plaintiff's second amended complaint.

In this appeal the principal question before us for determination is whether the said complaint sufficiently alleges a cause of action against the defendant. A secondary question is whether certain portions of the said complaint should have been stricken pursuant to the defendant's said motion to strike.

The basic allegations of the plaintiffs' second amended complaint are substantially as follows: That the plaintiffs, 57 in number, are the owners of lands on which they reside, in close proximity to the Imeson Airport, which is owned and operated by the defendant, a municipal corporation. That the city, commencing during World War II and thereafter, embarked upon a program of expanding the airport, acquiring additional lands both by purchase and by condemnation, some of it lying between the plaintiff's properties and the original airport location. That in 1962 the city completed an extension of the Northeast-Southwest main runway, under the directives and requirements of the Federal Aviation Agency for instrument runways, in order that the airport would become fully qualified to handle airplanes, both military and commercial, propelled by turbo-jet engines.

That the Northeast end of this extension of the runway abuts a county road running through the plaintiffs' residential area and the approach to that end bisects the said road, so that the said area has been severed and cut into two parts, lying on either side of the end of the extended runway. That the city provides facilities at the airport for the Florida Air National Guard, and maintains a squadron of jet fighter pilots who currently fly military fighter planes "which are the fastest and most powerful (and consequently noisiest) fighter planes in the world." That the city also provides landing and take-off facilities for several commercial airlines, which daily operate approximately 90 flights in and out of the airport, at all hours of the day or night, using jet transport planes, most of them four-engined.

The plaintiffs further allege in their said complaint: That the said planes, both military and commercial, are operated every day through the air space above the plaintiffs' properties, at altitudes usually below 500 feet, the most common altitude being between 100 and 150 feet, with some flights below 100 feet. That all of the plaintiffs' said properties are within the area designated and defined by the Federal Aviation Agency as "Area Recommended for Non-Residential Development and The Exclusion of Places of Public Assembly" in the Aircraft Noise Abatement Guide, published by the said agency in 1960 for the use and guidance of airport owners and operators who desire to provide airport facilities for the operation of jet-propelled aircraft.

The plaintiffs then allege in their second amended complaint that, by reason of the close proximity of the plaintiffs' properties, jet aircraft operated by the said Air National Guard and the said commercial airlines at times pass over the said properties at altitudes below 500 feet, the greater number of flights occurring at altitudes ranging from 100 to 150 feet: that while the said aircraft pass over the said properties or in close proximity thereto, and while landing, taking off, and warming up, and particularly while advancing the engines to near maximum power on the warm-up pads and taxiing strips appurtenant to the runways, the aircraft engines cause to be heard and felt "terrific and overwhelming vibrations, concussions and sound waves directed and transmitted from said engines" against and upon the plaintiffs' properties; that there are also emitted from the said engines "exhaust fumes, fuel gasses and heavy black smoke which are directed and transmitted" against and upon the said properties, which gasses, fumes, and smoke carry with them "dust, debris, earth, and stones" which are propelled against and upon the said properties; that the said vibrations and concussions cause dishes and windows to rattle in the plaintiffs' homes and make it impossible for the plaintiffs and members of their families to carry on any conversation, and on occasion have caused structural damage to the plaintiffs' residences and have caused objects to fall from tables and shelves.

On the subject of damages the plaintiffs allege in their said complaint that the above conditions occur at all hours of the day and night and at all times during the week, to the permanent injury and damage to their properties; that they are unable to secure an uninterrupted night's sleep due to the irregularity of the said flights of jet planes; that the plaintiffs have suffered great physical and mental discomfort, fear, and distress from the operations of the airport, particularly since the advent of jet planes, and the value of their properties "as residences or other use requiring the presence of human beings or animals has been destroyed." The plaintiffs re-aver their allegation that all of their properties are within the area recommended by the Federal Aviation Agency as not suitable for residential development.

In paragraph numbered V of their said complaint, the plaintiffs reveal what they conceive to be the nature of their cause of action against the defendant city, as follows:

"As a direct and proximate result of the increased operation of jet planes from Defendant's Imeson Airport, which increased operation has taken place within the past two years, the Defendant has deprived the Plaintiffs of the free and unmolested use and quiet enjoyment of their respective properties, and Defendant has, by so doing, exercised dominion and control over, appropriated, confiscated and condemned the properties of the Plaintiffs, without just compensation, and without due process of law, contrary to the Constitution and laws of the State of Florida and of the United States of America."

In paragraph VI of their said complaint the plaintiffs allege that by reason of the above-described conditions and of the depriving of the plaintiffs of their free and unmolested use and quiet enjoyment of their properties, and of the "confiscation and condemnation of their properties by the defendant the Federal Housing Administration and the Veterans' Administration" will not insure or guarantee any loan to any person to buy, build, or construct any home or other building on the plaintiffs' properties, and "no bank or other prudent lending institution will make a loan to any person for such purposes," and that: "By reason of these conditions, plaintiffs' properties have been condemned and made useless, as residential property, by the defendant, without due process of law, contrary to the Constitution and laws of the State of Florida and of the United States of America."

In paragraph VII the plaintiffs allege that, in conjunction with the defendant's expansion of the airport and in pursuance to a resolution adopted by it, the defendant had filed in the Duval County Circuit Court a condemnation action against certain of the plaintiffs, seeking to take an easement consisting mainly of the right to enter upon the properties of the said plaintiffs for the purpose of cutting trees and removing other obstructions above a certain height over their properties for the purpose of maintaining a clear zone for the flight of aircraft—the so-called "clearance easement"— but the said plaintiffs cannot in that action compel the city to condemn more property or any greater interest.

Finally, in the eighth and last paragraph of their said complaint, the plaintiffs allege that the operation of the said airport, as expanded by the defendant, "constitutes a continual trespass against the properties of the plaintiffs, or a nuisance equivalent to the imposition of a servitude upon the properties of the plaintiffs. Plaintiffs are thus irreparably injured, and their only relief is in equity."

The prayer of the plaintiffs at the conclusion of their complaint is as follows:

"Wherefore, Plaintiffs pray that an injunction issue against the Defendant prohibiting further continuance of the trespass or nuisance, or in the alternative that the Defendant be required to exercise its right of eminent domain as a means of making restitution to the Plaintiffs, and each of them, and that the Defendant pay to the Plaintiffs such attorney's fee as to the Court seems reasonable."

To the foregoing second amended complaint the defendant city duly filed its motion to dismiss and motion to strike. The stated ground for its motion to dismiss is that the said complaint fails to state a cause of action against the defendant. In its motion to strike the defendant moves to strike paragraphs IV and V of the said complaint and certain parts of paragraph IV on the grounds that the said allegations are "redundant, irrelevant, immaterial and seek to assert improper elements of damage against this defendant." From the order of the Circuit Court denying the defendant's said motions to dismiss and to strike, the defendant has taken the instant interlocutory appeal.

While the plaintiffs' second amended complaint does not contain the expression "inverse condemnation," it is apparent from the allegations of the complaint, and it is clear from the statements and contentions made by the plaintiffs in their appeal brief, that they are attempting to allege in their complaint a cause of action in inverse condemnation, as an alternative to the remedy of injunctive relief. This effort makes this a case of first impression in Florida, for we know of no decision in this state specifically recognizing inverse condemnation based upon airport operations.

In several jurisdictions, both state and federal, the courts have upheld inverse condemnation as a legally-recognizable cause of action, and it is our problem in the present appeal to determine whether such a cause of action should be recognized in the courts of Florida.

[1] Inverse condemnation has been defined as the popular description of a cause of action against a governmental defendant to recover the value of property which has been taken in fact by the governmental defendant, even though no formal exercise of the power of eminent domain has been attempted by the taking agency. Thornburg v. Port of Portland, 233 Or. 178, 376 P.2d 100 (1962); Martin v. Port of Seattle, 391 P.2d 540 (Wash.1964). To the same effect but using different words, the New York Supreme Court, Appellate Division, in Trippe v. Port of New York Authority, 17 A.D.2d 472, 236 N.Y.S.2d 312 (1962) said that inverse condemnation is a method of compensation wherein "an owner asserting a claim for appropriation of his property may pursue his right by an action in equity for an injunction, and for damages; the court may then, as an alternative to the injunction, make an award for the taking * * *."

Apparently the leading case decided by the state courts involving an action for inverse condemnation against an airport authority charging a taking on account of a noise nuisance, is Thornburg v. Port of Portland, 233 Or. 178, 376 P.2d 100, decided by the Supreme Court of Oregon in 1962. In that case the plaintiffs owned and resided in a dwelling house located about 6,000 feet beyond the end of a certain airport runway and directly under the glide path of aircraft using it, and about 1,500 feet beyond the end of a second runway, but about 1,000 feet to one side of the glide path of aircraft using that runway. This action in inverse condemnation was brought by the plaintiffs against the Port of Portland, which owned and operated the airport in question, the Portland International Airport. The defendant had the power of eminent domain and had used it to surround itself with a substantial curtilege, but its formal acquisition stopped short of the plaintiffs' land. The plaintiffs contended that flights from both of the said runways had resulted in a taking of their property. Their principal complaint was that the noise from jet aircraft made their land unusable. The two theories of their case were: that systematic flights directly over their land cause a substantial interference with their use and enjoyment of their land, which interference constitutes a nuisance, a continuing nuisance which, when maintained by government, amounts to the taking of an easement, or, more precisely, presents a jury question whether there is a taking; and, secondly, that systematic flights which pass close to their land but not directly over it, constitute the taking of an easement, for the same reasons. At the trial the jury denied to the plaintiffs the compensation which they sought in their action, and the plaintiffs appealed.

In a scholarly opinion in the Thornburg case, the Supreme Court of Oregon said that the specific question before it was "whether a noise-nuisance can amount to a taking." In discussing decisions involving this point, the court further said:

"Since United States v. Causby, 328 U.S. 256, 66 S.Ct. 1062, 90 L.Ed. 1206 (1946), and particularly since Griggs v. Allegheny County, 369 U.S. 84, 82 S.Ct. 531, 7 L.Ed.2d 585 (1962), we know that easements can be taken by repeated low-level flights over private land. Such easements have been found in actions against the federal government (Causby) and in actions against municipal corporations (Griggs). When such easements are said to have been taken, compensation must be paid to the owners of the lands thus burdened. This much appears to be settled."

After a learned discussion of the authorities on the subject of the noise of jet aircraft amounting to a nuisance and such nuisance ripening into a "taking," the Oregon Supreme Court in the Thornburg case reached the following judicial conclusion:

"If we accept, as we must upon established principles of the law of servitudes, the validity of the proportions that a noise can be a nuisance; that a nuisance can given rise to an easement; and that a noise coming straight down from above one's land can ripen into a taking if it is persistent enough and aggravated enough, then logically the same kind and degree of interference with the use and enjoyment of one's land can also be a taking even though the noise vector may come from some direction other than the perpendicular.

"If a landowner has a right to be free from unreasonable interference caused by noise, as we hold that he has, then when does the noise burden become so unreasonable that the government must pay for the privilege of being permitted to continue to make the noise? Logically, the answer has to be given by the trier of fact (subject to the usual exercise of the proper function of the court in screening the evidence). See Restatement, Torts, § 826, Comment d."

The judgment appealed from was then reversed and the cause remanded for a new trial.

An even more recent case in the state courts involving an action for inverse condemnation against an airport operator on account of the operations of jet aircraft is Martin v. Port of Seattle, 391 P.2d 540 (Wash. 1964). As in the case before us, the question confronting the Supreme Court of Washington was whether the plaintiffs therein had stated a claim for relief against the municipal corporation as the owner of an airport. The defendant was the Port of Seattle, owner of the Seattle-Tacoma International Airport, and the plaintiffs were property owners who sought, through this action, damages for the taking or damaging of their property for public use caused by nearby low altitude flights of jet aircraft landing and taking off from the said airport, resulting in a decline in the market value of their properties.

The nothernmost edge of the litigated area was approximately nine-tenths of a mile from the end of a certain runway, and jet aircraft in the process of landing passed over the central part of the area at altitudes of less than 500 feet. The lands of some of the plaintiffs were subjected to direct overflights of the jet aircraft, while other plaintiffs suffered no overflights. The Washington Supreme Court stated that the gravamen of the plaintiffs' complaint was the noise and vibration created by the jet aircraft rather than the physical invasion. The plaintiffs claimed that, when the said aircraft passed over or in close proximity, conversation is halted, sleep is disrupted, fear is caused, etc., by the noise, and the vibration in the houses makes it necessary periodically to hammer back nails into sidings and to tighten light fixtures, etc. The Supreme Court of Washington agreed with the lower court that the plaintiffs' complaint stated a claim for relief against the defendant, and affirmed the judgment appealed from.

In its discussion of the authorities in this field of law in the Martin case, the Supreme Court of Washington had this to say about the nature of the cause of action in the litigation before it:

"Whether the 'cause of action' for the recovery of compensation is viewed as resulting from the due process provisions of the Constitution, or as resulting from an adaptation of older ideas of eminent domain and the condemnation of private property for public use, is of little significance. When the noise and intense vibration produced by low-flying jet aircraft deprives the owner of land of an essential element in his relationship to that land, the result should be the same whether the airport operator himself brings the action to 'condemn' the right to so interfere with the land, or the landowner is forced to be the moving party."

In both of the Oregon and Washington cases which we have just discussed, the courts cited and relied upon the following two landmark decisions of the United States Supreme Court:

In the United States v. Causby, 328 U.S. 256, 66 S.Ct. 1062, 90 L.Ed. 1206 (1945), the United States Supreme Court held that repeated flights of aircraft at such proximity to the ground as to render property uninhabitable and diminish its value constituted a taking, notwithstanding the fact that the aircraft in their path of glide to and from the airport had conformed to the thirty-to-one glide angle approved by the Civil Aeronautics Authority. The Supreme Court stated that it was a case of first impression and that the problem presented was whether the respondents' property was taken within the meaning of the Fifth Amendment by frequent and regular flights of army and navy aircraft over the respondents' land at low altitudes. The respondents, Causby and his wife, owned land near an airport leased to the United States in North Carolina, on which land stood their dwelling house and various out-buildings which were mainly used for raising chickens. The Causbys filed this action against the United States in the U.S. Court of Claims to recover for the alleged taking of their property without compensation by flying airplanes across it at such height as to interfere with its normal use. The Court of Claims rendered judgment for the Causbys, and the United States sought review by certiorari in the Supreme Court. The evidence showed that the flights in question interfered with the normal use of the Causbys' property as a chicken farm and interfered with the night rest of the Causby family. About 150 of their chickens were killed by flying into walls from fright. Production also fell off. The result was the destruction of the property as a commercial chicken farm.

In the Causby case the United States Supreme Court gave the following as its reasoning leading to its conclusion that there had been a taking of the Causbys' property within the meaning of the Fifth Amendment to the Constitution of the United States.

"We would not doubt that if the United States erected an elevated railway over respondents' land at the precise altitude where its planes now fly, there would be a partial taking, even though none of the supports of the structure rested on the land. The reason is that there would be an intrusion so immediate and direct as to subtract from the owner's full enjoyment of the property and to limit his exploitation of it. While the owner does not in any physical manner occupy that stratum of airspace or make use of it in the conventional sense, he does use it in somewhat the same sense that space left between buildings for the purpose of light and air is used. The superadjacent airspace at this low altitude is so close to the land that continuous invasions of it affect the use of the surface of the land itself. We think, that the landowner, as an incident to his ownership, has a claim to it and that invasions of it are in the same category as invasions of the surface."

A somewhat analogous situation was before the Supreme Court in the later case of Griggs v. County of Allegheny, 82 S. Ct. 531, 369 U.S. 84, 7 L.Ed.2d 585 (1962). Griggs had instituted eminent domain proceedings in the Court of Common Pleas of Allegheny County, State of Pennsylvania, which held that there had been a taking by the county, which owned and operated an airport, of an air easement over his property, and fixed compensation therefor. The Supreme Court of Pennsylvania on appeal (County of Allegheny v. Griggs, 402 Pa. 411, 168 A.2d 123 (1961), held that, if there had been a taking, the county was not liable, and Griggs sought review of this reversal by certiorari in the U.S. Supreme Court, which reversed and held that the interference with Griggs' property amounted to a taking, in the constitutional sense, of an air easement for which compensation must be paid by the county, the owner and operator of the airport (the Greater Pittsburgh Airport).

In the Griggs case, one "approach area," as designed by the county, to the northeast runway passed over Griggs' home, which was 3,250 feet from the end of the said runway. The "slope gradient" of the approach area provided a clearance of 11.36 feet between the bottom of the glide angle and Griggs' chimney. The low-altitude overflights caused Griggs and the occupants of his property to become nervous and distraught, their sleep was disturbed, etc.

After discussing and re-affirming its holding in the Causby case, supra, the Supreme Court in the Griggs case said the following on the question as to who took the air easement in the constitutional sense:

"It is argued that though there was a 'taking,' someone other than respondent was the taker—the airlines or the C.A.A. acting as an authorized representative of the United States. We think, however, that respondent, which was the promoter, owner, and lessor of the airport, was in these circumstances the one who took the air easement in the constitutional sense. Respondent decided, subject to the approval of the C.A.A., where the airport would be built, what runways it would need, their direction and length, and what land and navigation easements would be needed."

In the final three sentences of its opinion, however, the Supreme Court uses language that we think touches the very heart of the concept of inverse condemnation:

"Without the 'approach areas,' an airport is indeed not operable. Respondent in designing it had to acquire some private property. Our conclusion is that by constitutional standards it did not acquire enough."

[2] Reverting now to the case before us on this appeal, we think that the allegations in the plaintiff's second amended complaint fall squarely within the rules laid down in the above-discussed four decisions of the Supreme Court of Oregon, Washington, and the United States, as averring a constitutional taking of their property, requiring the payment to them of just compensation by the owner and operator of the airport. The facts alleged in the plaintiffs' said complaint, are, we believe, substantially the same as the basic facts involved in the said four decisions. This being so, the sole remaining inquiry is whether there exists any legal reason why the rules recognized in those decisions should not be recognized and applied in Florida. We see no such reason.

This is a case of first impression in this State. We know of no Florida case specifically recognizing inverse condemnation based upon airport operations, although this court in our recent decision in Corbett v. Eastern Air Lines, 166 So.2d 196, we adverted to that type of action by way of pure obiter dictum.

The constitutional provisions applicable in Florida are consistent with, if they do not affirmatively require, the recognition of the concept of inverse condemnation. In addition to the provisions of the United States Constitution applied in the Causby and Griggs decisions, Section 4 of the Declaration of Rights in the Constitution of Florida, F.S.A. provides: "All courts in this State shall be open, so that every person for any injury done him in his lands, goods, person or reputation shall have remedy, by due course of law, and right and justice shall be administered without sale, denial or delay." Section 12 of the Declaration provides in pertinent part: "No person shall * * * be deprived of life, liberty, or property, without due process of law; nor shall private property be taken without just compensation. * * *"

On the subject of condemnation Section 29 of Article XVI of the Florida Constitution, F.S.A. provides in pertinent part: "No private property, nor right of way shall be appropriated to the use of any corporation or individual until full compensation therefor shall be first made to the owner, or first secured to him by deposit of money * * *."

[3] The concept of inverse condemnation can be readily accepted if we acknowledge the doctrine that a continuing trespass or nuisance may ripen into a constitutional taking of property within the ken of constitutional provisions prohibiting the taking of property without the payment of just compensation. Such a doctrine has been recognized in several decisions of the appellate courts of Florida.

For instance, in State Road Department of Florida v. Tharp, 146 Fla. 745, 1 So.2d 868 (1941), the owner of a water mill filed a suit to restrain the continuing of a trespass by the State Road Department which had erected a bridge and a fill which obstructed channels in which water flowed after it left the millrace, resulting in raising the elevation of the water in the millrace and in reducing the mill's capacity, or to require the department to exercise its right of eminent domain as a means of making restitution to the owner. The said owner contended that the building and maintenance of the fill amounted to a taking of his property without due process of law. The chancellor declined to issue the injunction, but granted to the department the privilege of exercising the right of eminent domain as a means of making restitution to the owner. A motion to dismiss was denied and on final hearing the chancellor granted the relief prayed for; and the department appealed.

In affirming the chancellor's decree in this Tharp case, the Supreme Court of Florida, speaking thorugh the late Justice Terrell, said the following with respect to the basic constitutional issues involved:

"If a State agency can deliberately trespass on and destroy the property of the citizen in the manner shown to have been done here and then be relieved from making restitution on the plea of nonliability of the State for suit, then the constitutional guaranty of the right to own and dispose of property becomes nothing more than the tinkling of empty words. Such a holding would raise administrative boards above the law and clothe them with an air of megalomania that would eternally jeopardize the property right of the citizens. It would reverse the order of democracy in this country and head it into a blind alley.

"American democracy is a distinct departure from other democracies in that we place the emphasis on the individual and protect him in his personal property rights against the State and all other assailants. The State may condemn his property for public use and pay a just compensation for it, but it will not be permitted to grab or take it by force and the doctrine of nonsuability should not be so construed. Forceful taking is abhorrent to every democratic impulse and alien to our political concepts.

"If American democracy survives and lives up to the function of its creation, it must do so by adherence to the code of moral and legal conduct promulgated by the Constitution, one provision of which is the sanctity of private property. No principle has contributed more to the material development of the country or done more to stabilize and balance its citizenship. To be a property owner and a taxpayer is one of the surest incentives to a dependable citizenship. It gives the citizen a stake in his government second to no other influence. It is one of the first duties of constitutional government to protect, and where the sovereign has a right to condemn for public use, it will not be permitted to appropriate except by orderly processes. The current of the law on this point will not lead to any other conclusion.

"Supporting this thesis, Section 12 of the Declaration of Rights provides that no person shall be deprived of his property without just compensation and Section 29 of Article 16 of the Constitution contains a similar specification with reference to corporations and individuals for the preservation of property rights. The latter provision is mandatory that the compensation be made before the property is appropriated."

[4] On the authority of the just-quoted decision of the Supreme Court of Florida, the above-quoted provisions of the Florida Constitution, and the above decisions from other jurisdictions, we hold that in the present case the allegations of the plaintiffs' second amended complaint are sufficient to state a claim for relief—either injunctive relief or by way of inverse condemnation—so that the chancellor correctly denied the defendant's motion to dismiss the said complaint. We also hold that the complaint's allegations attacked by the defendant's motion to strike are both relevant and material to the plaintiffs' cause of action, so that the chancellor correctly denied that motion also. Consequently, the order appealed from herein must be and it is

Affirmed.

Wigginton and Rawls, JJ., concur.

STATEMENT OF ALVIN G. GREENWALD, OF GREENWALD LANDRUM & BALM, ATTORNEYS AT LAW

Chairman Muskie and members of the committee, I appreciate this opportunity to present my views on and lend my support to S. 3229, title II. I am recommending: a "Domestic Tranquility Act"—To Enforce a Portion of the Preamble of the U.S. Constitution and Provide a Programmed Method for the Restoration of an Acceptable National Quietude Environment.

The environmental accomplishments of this subcommittee over the past four years are: the Federal Water Pollution Control Act; the Solid Waste Disposal Act; the Air Quality Act; and the National Emissions Act. These are accomplishments which project great promise that your present involvement in the field of NOISE will soon provide the public with solutions to "noise pollution" (the most neglected aspect of environmental distress).

PRESENT NOISE REDUCTION—AND LIMITATION OF FURTHER DEGRADATION—IS AT LEAST AS IMPORTANT AS FUTURE NOISE STUDY

Senate Bill 3229, which amends the Clean Air Act and adds the "Noise Pollution and Abatement Act," would provide up to $30,000,000 to the Department of Health, Education and Welfare (HEW) for the study of critical areas of noise and its effect. The propriety of the provisions of this act must be considered in the light of accumulated wisdom gained from extensive noise studies heretofore completed on a national basis. It serves limited purpose to be so consumed only with study of reasons why humans are being noise-polluted to death that we fail in the meantime to stop increasing noise pollution . . . stop it to the extent of already ascertained practical, economic, present capacity. We should stop the bleeding while the patient is alive rather than merely standing aside to study why the poor patient is bleeding to death.

NATIONAL POWER AND DUTY TO CONTROL NOISE POLLUTION EXISTS UNDER PRESENT FEDERAL REGULATIONS

The Preamble of the United States Constitution assures to all of the people of our country domestic tranquility. Tranquility may be defined at law as the state or character of being quiet—quietness. The Commerce Clause should be interpreted in a manner consistent with this purpose (tranquility). The will of the people in support of this purpose is evidenced in the Constitutions of the 50 states. Over 30 state constitutions extend human rights protections beyond our national constitution. Both the power and the duty to control noise on a national level already exists.

For example, transportation noise is within the purview of the "National Traffic and Motor Act of 1966" (compare the Federal Rules controlling buses, trucks and every driven motor vehicle to vehicular noise emission regulations enacted by the States of New York and California). The Department of Transportation also administers the Federal Aid to Airports Act under which billions of dollars of the peoples money have been turned over to municipally owned noisemaking facilities. The law recites limitation of grants to airports expanding into incompatible heavily populated residential areas. Incompatible grants uncontrolled by proper application of existing law defeat reasons for land use planning, no matter how well conceived.

MORE MONEY—LESS TIME—(FOR NOISE REDUCTION) ARE JUSTIFIED BY ALREADY ASCERTAINED HEALTH HAZARDS

The 30 million dollars HEW may spend on its future investigation and study—to prepare a report one year hence—is a smaller sum and a greater time period than should be allowed HEW to complete the job. Keying this observation to the seven study areas delineated by the proposed "Noise Pollution and Abatement Act", I respectfully refer this subcommittee to:

1. [Study of effects at various levels]—the study published in March, 1966, by the office of Science and Technology, executive office of the President, and the documented findings of Karl D. Kryter and William F. Galoway. Their reports not only identify the advanced state of noise technology but also the measurement and testing techniques related to the effects of noise pollution at various levels.

2. [*Study of Noise Level Increase in urban areas through the year 2000*]—the studies conducted by Bolt, Baranak and Newman (1965) under the auspices of the F.A.A. Their *Noise* Exposure Forecasts through 1975 show intolerable conditions to residents over an expanding area. Validation of their *Noise* Exposure Forecasts (NEF) in the Los Angeles Basin has already been experienced. Two schools have been closed to accommodate *noise* pollution. Students from these schools have been shuffled into already overcrowded facilities reducing the educational qualities of this community. Thirty-eight additional schools in the Los Angeles Basin are threatened with closure to accommodate *noise* pollution. The Los Angeles Board of Education is suing the Los Angeles Airport for over One Hundred Million Dollars in damages. The known burden of *noise* pollution on educational facilities is the subject of an extensive report prepared for the L.A. Board of Education in 1967.

3. [*Study of the psychological effect on humans*]—the 1968 finding of the Surgeon General of The United States was: "*Noise Is Dangerous to Health.*" The Surgeon General also found: *noise* induces hearing loss; *noise* damages the cells of the ear; *noise* damages the cardio-vascular and glandular systems; *noise* causes respiratory reflection of stress; *noise* reduces efficiency and *noise* damages individuals' capacity to work and to concentrate; *noise* results in leisure retardation; *noise* effects the quality of human living and damages the human atmosphere for self-fulfillment.

4. [*Study of sporadic as compared with constant Noise*] . . . the Walsh-Healy Act, Noise Amendment, established under Federal law to protect that segment of our population that should have the strongest ability to withstand *noise* stress—the workers. In May, 1969, numerical standards for both constant and impact *noise* limitation exposure levels were adopted. Britain in 1960 developed a *noise* number index composite rating for the purpose of taking into account the well-established variables incident to jet *noise* near airports such as number of incidents per hour, duration of incident, distance of *noise* source, propagation path variables, etc.

5. [*Study effect on wildlife and property*]—the Environmental Report published by Bureau of National Affairs (BNA), Washington, D.C. 1970 reports that animal and plant life have sound sensitivity many times greater than man. Laboratory tests on animals' reaction to human intervention in the rhythm of nature by unnatural noise exposure (even though many animals are naturally equipped with ear covers) have induced mutation and death from *noise*. *Noise* "clear zones", to accommodate airports, highways and industrial activities, destroy natural growth in life support areas. Bird life, for example, causes millions of dollars worth of aircraft damage each year. Besides preventative extermination programs to discourage bird life in air route areas, removal of natural growth, food and nesting support is accepted practice. As to property damages, Fortune Magazine (October 1969) reports that there are up to 3 billion dollars in claims being pursued for jet *noise* damages in the L. A. Basin area.

6. [*Study of effect of sonic booms on property*]—the recent repudiation by this country of the advice from the Panel of noted authorities on the sonic boom, the announcement of the decision to go forward with the SST, is so staggering as to require further official study and explanation.

7. [*Study of other matters*]—TVASNAC Quotes, Vol. 2, #2, reports that this year NASA will spend 18 million, DOT 5 million, USAF 2.5 million and aircraft industry, 18 million—a total of 37.5 million on study of aircraft *noise* reduction. The sum of 30 million dollars as proposed by the bill may seem like a lot of money until it is related to the sums being spent on Federal Pollution-Creating Facilities as Compared to Federal Pollution Abatement Activities. From a survey conducted by the law offices of Greenwald, Landrum and Baim this year on the *Noise* Budget allocations of each State and each Federal department, it appears the published cost of expanding the Los Angeles Airport Department facilities (over 500 million) will exceed the total expenditure during 1970 for all types of pollution research, development and demonstration (RD&D) by the Federal Government, including air, water, land, solid waste, pesticides, radiation, thermal, *noise*, food and other pollutants (less than 400 million). Of this 400 million, less than 25 million is budgeted for *noise*. In addition to the Department of Transportation (DOT), the Department of Housing and Urban Development (HUD) has been expending funds on dwelling *noise* evaluation, the Department of Labor (DOL) on hearing conservation and *noise* exposure ratings, Department of Interior (USDI) on effects of *noise* on the

natural environment, Department of Commerce (COMM) on *noise* relations and their effect on the national economy.

Last year a most significant contribution in the *noise* law field was made by the Department of Commerce. (See also budgets of USDA, AEC, DOD, NSF, etc.) The work of each of the departments in the environmental *noise* field is commendable, particularly in view of their lack of adequate funding. The National pollution problem is of sufficient magnitude that it requires interdisciplinary input of the accumulated wisdom of each of these departments so as to avoid duplicating RD&D efforts and promote the creation of *noise* criteria, *noise* standards, *noise* measurement procedures, *noise* legislation and *noise* education at an early date commensurate with the known national *noise* plague in which we find ourselves.

DOMESTIC TRANQUILITY CAN BE ACHIEVED THROUGH FEDERAL LEGISLATION

This speaker takes full responsibility for proposing a new "Domestic Tranquality Act," an original concept which the speaker has developed in detail for intended future publication by the Bureau of National Affairs, Washington, D.C. It provides:

1. That the Domestic Tranquility Act be administered under an overview Environmental "Life Quality"—"Life Style" Department as a part of a Systems approach to coordinate "anti-pollution"—"Pro-environmental" governmental activities.
2. That rules of regulatory departments be amended to appropriately add as a *national objective*—Domestic Tranquility—consistent with a desirable "Life quality" for *individual human persons and* for their *employers* who provide their jobs and contribute to their "life style" . . . with appropriate amendments to facilitate . . . and achieve objectives consistent with sound national economic policies. *If "Peace & Quiet."*
3. That *anti-trust exemptions* be *granted* to all segments of *industry* from the threat of anti-trust and monopoly laws . . . including, without limitation, Sherman Act, Robinson Patman Act, Clayton Act, and Federal Trade Commission Act *as to products and conduct expressly authorized* under the Domestic Tranquility Act as an economic *noise* reduction inducement.
4. That the 1970 *Federal Tax* Reform Bill granting accelerated depreciation for anti-pollution equipment be expanded to grant *direct deduction for pro-environmental developments* expressly authorized under the Domestic Tranquility Act as an economic *noise* reduction inducement.
5. That the Domestic Tranquility *Grants* provide funds *to polluted communities* for use by them for tranquility control purposes in sums commensurate with grants awarded to pollutors (such as public works, airports and transportation facilities) with the objective of *shifting a part of the Federal Aid from the non-conforming pollutor to the pollutee* . . . that urban land use planning and urban area zoning standards compliance be a condition to grant of Federal public funds for use in expansion of polluting activities as defined under the Domestic Tranquility Act.
6. That the Domestic Tranquility Act include in its administration a "*Citizens Advisory Committee*" with ¼ of its members representing *industry*, ¼ representing *scientific community*, ¼ representing *government* and ¼ representing *polluted urban homeowners* . . . that the purview of the act include hearing conservation for non-employees; *noise* standards for buildings, construction supplies, equipment and procedures; consumer *noise* disclosure requirements; public and recreation lands *noise* criteria; government, equipment and operations, acquisition and control.
7. That the Domestic Tranquility Act adopt *noise* reduction, budget-type performance standards, *subsidize* producers and operators of *quieter equipment and quieter procedures* and *limit* producers of *noisier equipment* and *noisier procedures* . . . establish a "*noise damage trust fund*" for the benefit of pollutees, created by pollution violation fines and penalties with the objective of shifting a part of the cost of pollution from the pollutee to the non-complying pollutor.

Senator RANDOLPH. We will recess until tomorrow morning at 9:30.

(Whereupon, at 12:17 p.m., the subcommittee recessed, to reconvene at 9:30 a.m., Wednesday, March 25, 1970.)

AIR POLLUTION—1970

WEDNESDAY, MARCH 25, 1970

U.S. Senate,
Joint Meeting of the Subcommittee on Air and
Water Pollution of the Committee on Public
Works and the Commerce Committee,
Washington, D.C.

The joint meeting reconvened at 9:30 a.m., pursuant to recess, in room 4200, New Senate Office Building, Senator Thomas F. Eagleton, presiding pro tempore.

Present: Senators Randolph, Spong, Eagleton, Boggs, and Dole.

Also present: Senators Hartke, Hart, and Pearson.

Staff members present: Richard B. Royce, chief clerk and staff director; M. Barry Meyer, counsel; Bailey Guard, assistant chief clerk; minority Tom Jorling, minority counsel; Leon G. Billings and Adrien Waller, professional staff members.

Senator Eagleton (presiding). Good morning, ladies and gentlemen.

The meeting this morning is a joint meeting of the Subcommittee on Air and Water Pollution of the Committee on Public Works, as well as the full Commerce Committee, to continue public hearings on S. 3229, S. 3466, and S. 3546.

We are now being joined by Senator Hart of Michigan and other members of both committees who will be with us from time to time throughout today's hearing.

Our first witness this morning is Mr. Stuart G. Tipton, president, Air Transport Association of America.

Mr. Tipton, I notice you are accompanied by individuals. Would you please identify them from left to right for the record.

STATEMENT OF STUART G. TIPTON, PRESIDENT, AIR TRANSPORT ASSOCIATION OF AMERICA, ACCOMPANIED BY CLIFTON F. VON KANN, VICE PRESIDENT, OPERATIONS AND ENGINEERING, AND WILLIAM BECKER, ASSISTANT VICE PRESIDENT IN CHARGE OF OPERATIONS

Mr. Tipton. I will do so, Mr. Chairman.

First I want to thank the committee for giving us this time to appear.

On my left is Gen. Clifton Von Kann, vice president of Operations and Engineering of the Air Transport Association.

On my right is Mr. William Becker, assistant vice president of the Association in Charge of Operations.

Mr. Chairman, my name is Stuart G. Tipton. I am president of the Air Transport Association, the trade and service organization which represents virtually all the scheduled, certificated airlines of the United States. I want to thank you again for providing us this opportunity to present testimony with respect to S. 3229 and to discuss briefly the industry program to abate jet aircraft smoke emissions.

AIRLINES SUPPORT S. 3229 OBJECTIVES

The scheduled airlines believe S. 3229 is a good bill, and we support its objectives. We welcome the incorporation of aircraft into Federal legislation which will deal effectively with pollution of the air. Such legislation is most timely and we urge that it be enacted without undue delay.

At the outset I should like to make a few general comments concerning S. 3229. The bill would, among other things, vest in the Federal Government specific authority to establish national emission standards with respect to aircraft and their engines. We believe this is appropriate and a constructive first step in assuring a single nationwide standard to be applied to aircraft emissions.

The existing provision of the Clean Air Act dealing with State motor vehicle emission standards would remain unchanged. We would like very much to see aircraft included in this provision.

The bill proposes to establish an office of noise abatement and control in the Department of Health, Education, and Welfare.

We can see no objection to the establishment of such an office, the purpose of which is to investigate and study noise and its effects, and to recommend to Congress and to the President appropriate legislation. We must urge strongly, however, that this office be required to consult with, and coordinate its activities closely with the Department of Transportation, which has for some time had an Office of Noise Abatement. We suggest further that the HEW Noise Abatement Office also consult with the National Aeronautics and Space Administration, which has done, and is doing, considerable research in the field of aircraft noise and sonic boom.

We have some specific comments to make with respect to the various provisions of S. 3229. First, however, I would like to briefly review for the committee the airline antipollution program. We believe our efforts are constructive and substantial. I think you will agree.

THE AIRLINE ANTIPOLLUTION PROGRAM

Several years ago the airlines decided that smoke emissions from jet engines should be reduced to the lowest practical level, even though they represented a very small percentage of pollutants from all sources, and even though little, if any, Government attention had been directed to aircraft emissions. In fact, as recently as March 1969 the Secretary of Health, Education, and Welfare indicated in his report to Congress on aircraft emissions that statutory authority or other Federal regulatory action was unnecessary at this time.

The airline industry joined with the engine manufacturers in a program to produce an experimental combustor for the JT 8–D engine, which powers the Boeing 727 and 737, and the McDonnell Douglas DC–9. The JT 8–D engine was selected because it emits a plume of smoke which appears denser than that of other jet engines, and because the three aircraft types using the engine make up half the current airline fleet. It was estimated that if an improved combustor could be designed to virtually eliminate smoke from the JT 8–D, the result would be the elimination of about 70 percent of airline smoke emissions.

A new technology combustor, or "burner can," was not an easy thing to achieve. About 99 percent of jet exhaust gases are noncontaminating elements such as carbon dioxide, water vapor, oxygen, and nitrogen. Much of the remaining 1 percent is nontoxic unburned carbon caused by incomplete combustion. The crux of the problem, then, was to further reduce this already minute jet emission product.

To make a long story short, the job was done, and pending successful flight testing of the new combustor, the airlines made plans to retrofit all JT 8–D engines. While this program was being formulated and before even half the flight testing had been completed, a number of States began to show interest in jet aircraft emissions. Law suits were brought in New Jersey and Illinois. Subsequently, Michigan, New York, California, Missouri, Minnesota, Massachusetts, and Maryland either filed suit, demanded through legislation that airlines cease polluting the air, or asked the carriers to submit schedules for smokeless burner can replacement.

In January of this year the Secretary of Health, Education, and Welfare and the Secretary of Transportation held a meeting with the airlines at which 31 airlines agreed to a schedule of JT 8–D engine retrofit which would be substantially completed by the end of 1972—about 1 year sooner than planned. The carriers are now making preparations to install the new combustors subject to timely delivery by the manufacturers.

The airlines have been guided in their efforts by the logic that environmental problems (including aircraft emissions) should be approached in two phases. The objective of the first phase would be to stop pollution from increasing. The aim of the second phase would be to reduce the problem to an acceptable level.

With respect to smoke emmissions the airlines have completed the first phase. The new wide bodied jets—the Boeing 747, the Lockheed 1011, and the McDonnell-Douglas DC–10—will be virtually devoid of smoke. Ninety-five percent of planned aircraft investment is for these new generation airliners. All new 727, 737, and DC–9 engines will be fitted with the new smokeless combustor, and as the JT 8–D engines on existing aircraft are retrofitted, smoke will be progressively reduced. The airlines will soon be well along into the second phase. I would guess that few other industries could claim similar results in the war against pollution.

Since, during this comment on the airline antipollution program, I will be constantly referring to burner cans, I thought I would just bring up a burner can so everyone can have in mind what the thing looks like. There are nine of those on each engine.

Senator EAGLETON. I though that was the other witness with you. It looks like Herbloc's cartoon of Melvin Laird.

Mr. Tipton. In a sense, this is, of course, a witness. This is what a good bit of the aircraft smoke discussion is about.

In the process of describing this antipollution program, I want to take a few moments to present some slides which will demonstrate the efforts and its results better than I could do just by words. So if you will turn to the slides, I will comment on them as we go along. This is a very brief slide show.

[Slide shown.]

The airlines recognize the contamination of the air through which they fly must be stopped. Working together, airlines and engine manufacturers long ago took the initiative to help reduce their contribution to air pollution. The results are shown by the progress we have made over the past 10 years in reducing black smoke from jet engines.

[Slide shown; see fig. 1.]

If you have forgotten, this is how the first jets looked taking off, using water injection. Next came the turbofan engines, without water injection, which greatly reduced takeoff smoke.

[Slide shown; see fig. 2.]

Our newest aircraft are the wide body jets—Boeing 747, McDonnell-Douglas DC–10 and Lockheed L–1011. [Slide shown; see fig. 3.] These aircraft use new technology engines two and a half times as powerful as those on earlier four-engine jets. As you can see from this 747 takeoff, its engines are virtually smoke free. [Slide shown.]

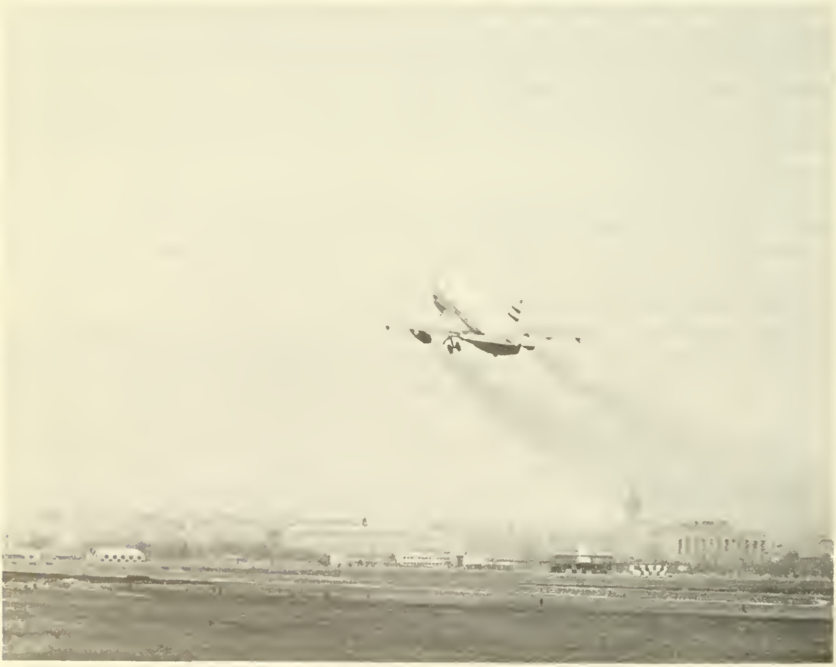


Figure 1

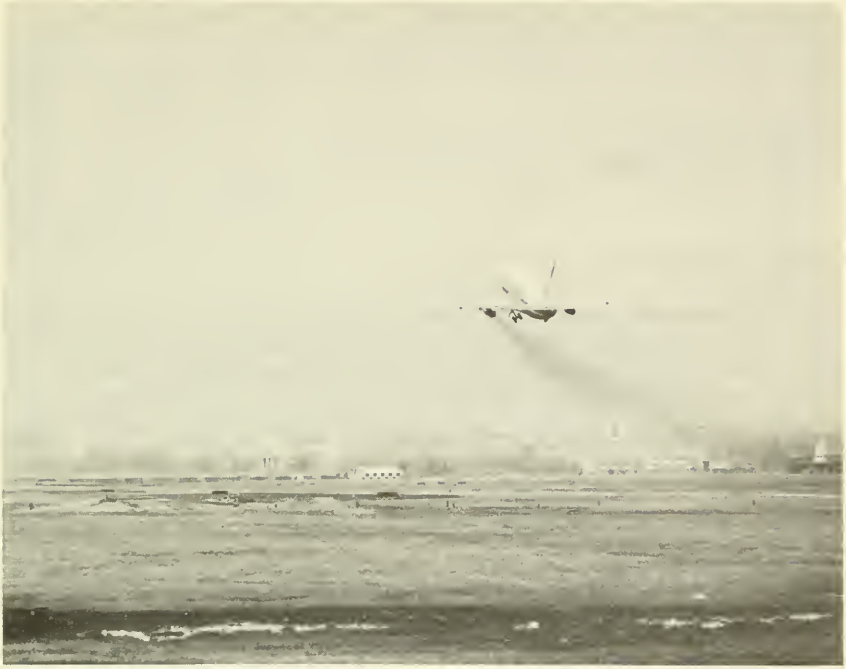


FIGURE 2

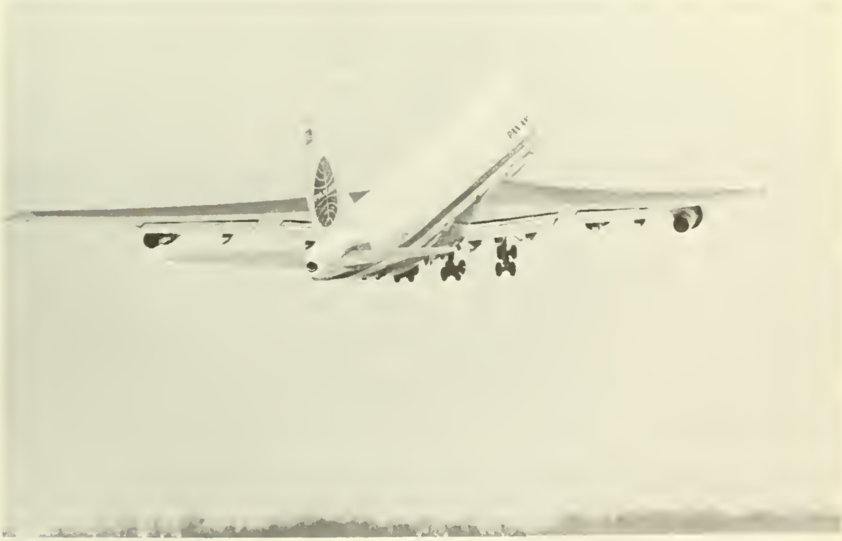


FIGURE 3

NEW AIRCRAFT ADDED TO FLEET—U.S. SCHEDULED AIRLINE INDUSTRY (AS OF DEC. 31, 1969)

	Present fleet	On order, 1970–75	Investment (billion dollars)
1. Wide-body jets with quieter, less smoky, new technology engines (747, DC-10, L-1011)	4	265	5.500
2. Small jets with JT8-D and planned retrofit (727, 737, DC-9)	965	47	.271
Total		312	5.800

Source: Air Transport Association.

Over the next 6 years 265 of these virtually smoke-free aircraft will enter the airline fleet. This represents an investment of $5.5 billion, which is also an investment in smoke abatement. (Slide shown.)

We have passed an important milestone: the increase of smoke pollution from new aircraft has been halted. We are also engaged in an industry program to reduce the smoke from aircraft already in the fleet. This program is based on the industry's decision 5 years ago to concentrate first on reducing smoke emissions from the Pratt & Whitney JT8–D engine, which powers the three engine Boeing 727, the twin engine Boeing 737, and McDonnell-Douglas DC–9. (Slides shown.) These three aircraft make up half of the airline fleet, but account for more than half the landings and takeoffs because they operate on short routes with frequent stops.

The smoke you have seen is unburned carbon which is produced by less than 1 percent of the fuel burned by the jet engine. (Slide shown.) Reducing this smoke means improving the combustion process to the point where more of the fuel is burned—without at the same time making the mixture so lean that it is hard to relight the engine after flameout or shutdown in flight. (Slide shown.)

Here you see the reduced smoke combustor design finally selected after 3 years of testing by Pratt & Whitney. Out of 500 designs tested on rigs, 200 were selected for further tests on full-scale engines. The design finally chosen was then run for 200 hours to qualify for FAA certification and airline use. Then, in the summer of 1968, 37 engine sets of these combustors were delivered to four ATA member airlines for in-service operational evaluation, to find out what didn't work, what needed improving, and give this information to the manufacturer so that it could be fixed before widespread airline use. At the same time, the airlines announced their intention of fitting all JT8–D engines with the new comustor, if the evaluation produced satisfactory results.

The amount of smoke reduction produced by this new combustor design is impressive. (Slide shown.) Here is a 737 with conventional smoky combustors. Next, look at the right engine of this 737 (slide shown)—one of the engines undergoing in-service evaluation. On January 20, 1970, 31 U.S. airlines announced they would soon begin installing the new combustors at regularly scheduled overhauls of the JT8–D engine and that this retrofit program would be substantially completed by the end of 1972. This program will take care of more than two-thirds of the exhaust smoke from jet engines now in service. (Slide shown.)

Reduced smoke combustors cannot be installed in an engine while it is still on the airplane. The engine must first be removed from the airplane—here, the middle engine of a Boeing 727 (slide shown)—then it goes into the overhaul shop to be stripped down and taken apart. The fan ducts in the front part of the engine are removed (slide shown) and the front, or cold, section, top of picture, is separated from the rear, or hot section, bottom of picture. (Slide shown.) Here you see the hot section opened up, with three of the nine combustors already removed.

Airlines with adequate shop facilities can rework the combustors, with kits supplied by the manufacturer. In that case (slide shown) the combustor is cut open, modified, (slide shown) and then welded back together. Next the nozzles (slide shown) that spray fuel into the combustor are rebuilt and tested on a special test rig. (Slide shown.) After this, the fuel control system is rebuilt (slide shown) and tested. (Slide shown.) Then the fuel system is put together and balanced. (Slide shown.) Finally, the engine is built up (slide shown) and moved to the test cell where during 4 to 5 hours, it is run at various power settings (slide shown) to verify that it is now ready for use in passenger service. When the test run is successfully completed the engine is finally ready for installation (slide shown) in a waiting airplane. (Slide shown.)

In conclusion, the program to reduce smoke from jet engines was begun at industry initiative, (slide shown) and has already produced impressive results. (Slide shown.) The airlines and engine manufacturers will continue to contribute their experience and know-how to the overall goal of improving the quality of the air we breathe.

That concludes the showing of the slides.

The effort to eliminate smoke from jet aircraft will be a success. Although we do not yet know how to control smoke from currently used engines other than the JT8–D, the airlines have addressed the engine manufacturers to develop a solution for the JT3, which powers the Boeing 707 and McDonnell-Douglas DC–8. Work on that problem is in progress.

Aside from curing the smoke problem, what about the nonvisible emissions? We know the amount is quite small. We also know that the new generation aircraft engines emit relatively fewer nonvisible pollutants than current ones. Quite frankly, however, no one has the answers to the myriad questions which could be raised about this subject; that is the subject of nonvisible emissions. As of now the problem, if there is one, has not yet been defined. To what extent, if any, do these nonvisible emissions contribute to pollution of the air? No one—neither government, science, nor ecology experts—has been able to tell us. As a result, the airlines are trying to find the answers on their own. We have created a top-level committee of airline officers whose sole function is to get those answers. Members of the committee include legal, medical, meteorological, and engine specialists—all experts in their fields. If the answers are to be found, you can be sure we shall find them.

I might say at this point that we have developed a slide presentation which depicts the airline-manufacturer smoke abatement program, and which graphically demonstrates the success of this effort. It has been pared to about 5 minutes, and I would urge you, Mr. Chairman, to permit us to show it to you and your committee.

RECOMMENDED CHANGES

As I indicated earlier, the airlines believe S. 3229 is a good bill. If the airline industry were not so intensively regulated, the bill would be perfectly all right as written. Because the industry is so heavily regulated, particularly with respect to the development, manufacture, operation, and maintenance of the engines we use, it is imperative that any legislation dealing with those engines must not duplicate, or conflict with, existing regulation.

The problem that arises is one of government organization within the executive branch. Unless there is a clear, logical, and proper division of responsibility between the Department of Health, Education, and Welfare and the Department of Transportation, we are fearful that confusion, expense, and delay will result from attempting to apply the provisions of S. 3229 to aircraft and their engines.

In attempting to assure this clear delineation of function, we have drafted some recommended changes to S. 3229. We sincerely hope the committee is sympathetic to our position. The alternative, we fear, would be regulation which is both expensive and awkward to administer. A synopsis of our recommendations follows.

1. *Application of Emission Standards.*—We know that HEW has the experts on pollution. It is fitting and proper that standards, rules, and regulations dealing with all forms of pollution should be issued by that Department. On the other hand, the Federal Aviation Administration has the experts on safety, operation, and engineering of aircraft and aircraft engines. Neither agency should interfere with the proper function of the other.

In this case, we feel strongly that while HEW should set the standards, FAA must retain authority over the application and enforcement of such standards to aircraft and their engines. We therefore recommend the addition of language to accomplish this purpose at the end of section 202(c).

2. *Certification.*—We think efficient regulation requires that there be no certification of aircraft and aircraft engines by the Secretary of HEW under section 206. Under that section, the Secretary of HEW is directed to test, in such manner as he deems appropriate, any aircraft or engine to determine whether it is in conformity with section 202 regulations. The Secretary may issue a certificate of conformity upon such terms as he may prescribe. Aircraft and engines used in commerce are to be "periodically certified under such procedures as the Secretary may by regulation prescribe."

This provision again imposes a flat duplication of a function which FAA already performs very thoroughly. Based upon a clear division of responsibility between HEW and FAA, we strongly recommend that the Federal Aviation Administrator continue to be the sole source of certification. The provisions of section 202, together with our recommended alteration of subsection (c) of that section should provide the Secretary of HEW with all the authority he needs or should have with respect to aircraft and aircraft engines.

3. *State Standards.*—As the bill is now drafted section 208, relating to Federal preemption of emission standards, does not include aircraft and aircraft engines as do other provisions of the bill. This can easily be corrected by inserting the words "aircraft" and "aircraft engines" in the appropriate places. As the committee knows, the Federal Government exercises very extensive regulation over the airline industry, and in the case of safety, such regulation is total. We are certain you will agree that the same exclusivity of jurisdiction should exist in the case of aircraft emissions. As the report of the Secretary of HEW to Congress entitled "Nature and Control of Aircraft Engine Exhaust Emissions" states:

> It is the Department's conclusion that adoption and enforcement of State or local emission control regulations pertaining to aircraft cannot be adequately justified at this time. The Department recommends that, if and when regulations become necessary, the rationale used to develop Federal rather than local emission standards for motor vehicles be applied to aircraft. (Sen. Doc. No. 91–9, at page 5.)

The case for a single, Federal standard for aircraft emissions is, of course, far more compelling than for motor vehicle emissions. The great preponderance of the aircraft of U.S. certificated airlines operate into many States in a single day. By way of illustration, the schedule of one aircraft of a major carrier shows that in the course of a single day, 10 points are served in nine States. The aircraft flies over a total of 17 States in that 24-hour period.

Just to illustrate further how farflung that is, it begins its day in Salt Lake City, moves to Boise, Portland, Seattle, Milwaukee, Cleveland, Pittsburgh, then to Atlanta, Tampa, then to Miami.

So that it would be onerous in the extreme to expect an airline company to comply with a different air pollution standard in each of the States or localities it serves.

We would further propose that there is no reason to apply to aircraft section 208(b), relating to waiver of preemption. Again, the problems of motor vehicles and aircraft are widely disparate. We can conceive of no circumstance which would warrant a State aircraft emission standard, rule, or regulation to be at variance with the Federal one. Nor should subsection (c) apply to aircraft, since the authority of State with respect to intrastate regulation of aircraft is clearly established under the Federal Aviation Act of 1958, and aviation safety is clearly an exclusive Federal function under that act. The courts have so held.

4. Prohibited acts.—Section 203 prohibits the manufacture or use in commerce of aircraft or aircraft engines not in conformity with regulations prescribed under section 202 except as provided in subsection (b). Section 203(a) (1) and (2) should be amended to add subsection (c) as an exception, or in the alternative, the section should be amended to eliminate all references to aircraft or aircraft engines. If an aircraft or engine is certified by FAA for emissions, as well as for safety and noise, and the aircraft or engine is operating according to specification, no additional prohibition is required.

5. Fuel additives.—In reviewing S. 3229, we discovered a preexisting provision of the Clean Air Act, section 210, which gives the Secretary regulatory power over all types of fuel. If this were to be applied to aircraft fuel, it would duplicate authority already residing

in the Federal Aviation Administration, which certificates engines and, within that certification process, approves specifications for fuels permitted to be used on each type engine. Neither fuels nor fuel additives are permitted to be used unless they are approved by FAA.

The authority given the Secretary of HEW in section 202 to set standards that determine the acceptable levels of exhaust emissions would seem to be adequate for the purpose of improving air quality. It is difficult to see why additional authority over aircraft fuels is necessary, especially in the light of FAA's existing authority. We, therefore, urge the committee to amend the bill to exempt aircraft fuels from the application of section 210.

6. Technical amendment.—If the committee agrees that HEW certification under section 206 is improper for aircraft and engines, section 213(1) which defines the term "manufacturer," should be amended to exclude the reference to aircraft in relation to section 206.

CONCLUSION

In conclusion, let me say the programs we have described will virtually eliminate smoke pollution from airline aircraft engines within the next few years. As soon as we determine the facts with respect to nonvisible emissions, the airlines will engage in a vigorous program aimed to do all we can to eliminate these.

Unquestionably these programs will be expensive. In one way or another, the funds to pay for them will come from either industry or Government. These funds must be extracted either from customers or taxpayers.

In any event, the more that industry can accomplish with its outlays, the less the Government will have to do. This means that both the Government and the airlines have a large stake in a businesslike, well planned, and efficient program of environmental improvement. We are establishing such a program. We hope the Government will support it and resist the temptation to engage in crash programs; for while these make headlines today, they will result in added costs to the public tomorrow.

If it is applied in an evenhanded way, and if the amendments we urge today are adopted, S. 3229 can be a highly useful mechanism for the elimination of aircraft emissions. The airline industry is a responsible one, fully imbued with awareness of its duties to the public. With the cooperation of the Government, we shall vigorously respond in the fight for cleaner air.

That concludes my statement, Mr. Chairman.

Senator EAGLETON. Thank you very much, Mr. Tipton.

Because we have present six Members of the Senate, we will invoke the so-called 2-minute rule alternating from left to right.

Before I propound a few brief questions to you, Senator Boggs is going to attend a meeting of the Post Office Committee which, you can imagine, is a very important one, so I am going to yield to Senator Boggs for his questions at this time.

Senator BOGGS. Thank you, Mr. Chairman. You are very kind, and I do have to attend a conference between the House and Senate conferees on postal legislation.

I want to compliment Mr. Tipton on his presentation. I think it is a great contribution to our considerations, Mr. Tipton.

I notice in your testimony that you approve the proposed new Office of Noise Abatement, but I was wondering if you have any thoughts in relation to that and the so-called problem of the sonic boom. Can you elaborate any further on that? Is there progress being made on the sonic boom as far as SST is concerned, and so forth?

Mr. TIPTON. I think that I will ask General Von Kann to comment on that, if that is all right.

Senator BOGGS. Yes, we appreciate that.

Mr. VON KANN. Thank you, sir.

Yes, we are impressed by the research that is going on toward perhaps not eliminating, but let's say muting, the sonic boom. Probably more money could go into this type of research, which is true of many types, but there is an effective Government program underway and I feel that with the technological excellence that we enjoy in our industry that we should be able to look forward to a significant improvement in this area.

I also think if you will, sir, that the sonic boom as it presently exists is not too well understood and as more and more is learned about the sonic boom in its present relation to airplanes, I think we will make progress toward eliminating this very serious problem.

Senator BOGGS. Very good. Thank you.

Mr. Chairman, I just have two other questions.

On the fuel additives at the present time, you say the FAA has the authority to certify engines and specifications for fuel and any additives used would have to be approved and certified by the FAA.

Mr. TIPTON. They would.

Senator BOGGS. Are there any additives used now?

Mr. TIPTON. I think that I better not try to answer that. I am going to ask Mr. Becker to answer.

Senator BOGGS. Surely.

Mr. BECKER. Today fuel additives are not used in scheduled operations. There are limited additives in cleaning the engine in the shop but nothing during transportation, even training flights.

Senator BOGGS. I see. Thank you.

Mr. Chairman, I don't want to take all my 10 minutes.

In conclusion you indicate that a so-called crash program would not necessarily be helpful, it might add to the overall expense of the thing and would not accomplish any more, that a reasonable approach is a few years. Would you indicate what you mean by a few years?

Mr. TIPTON. I think that I can answer that in principle better. In any event, whatever happens in the elimination of aircraft pollution or any other pollution it is going to be terribly expensive. I think that that is recognized by everyone and one of the really great problems in dealing with this difficulty is to figure out how to finance it. The thrust of my remarks here are that—let us take the economy of achieving the result into account. If money can be saved by extending a program for a reasonable period, then it should be appropriate to save the money in order that it can go to other elements of improvement. That is, I didn't have any particular period of time in mind.

My only urging here is that the accommodating expense of taking any steps must be taken into account in determining programs for air pollution control.

Senator BOGGS. In other words, it is kind of hard to say 1, 2, or 3 years, but you would not want to do anything other than with deliberate speed?

Mr. TIPTON. That is right.

Senator BOGGS. Thank you very much.

I thank you, Mr. Chairman.

Mr. Chairman, several provisions in the bills before the committee on the subject of these hearings go to the registration and regulation of fuels and fuel composition. One of the innovative provisions in the administration's bill, S. 3466, section 5, to amend section 210 of the Clean Air Act, provides for the regulation of fuels and fuel composition by the Secretary of Health, Education, and Welfare. Much of the testimony we have received, including today's testimony, is directed to this provision.

I would like to bring to the attention of the committee, and include at this point in the record of hearings, a press release from Secretary Finch to the executives of the Nation's petroleum companies initiating an effort to achieve voluntary removal of lead from gasoline. The letter recognizes that legislation is pending, but is premised on the belief that progress can be made in advance of legislation.

I commend the Secretary for this action for, as we all know, we cannot begin too soon to bring the internal combustion engine into compliance with stringent emission requirements.

Senator EAGLETON. Your letter and release will be made part of the record.

Senator Boggs. Thank you very much, sir.

(The release and letter follow:)

HEW NEWS—FOR RELEASE TUESDAY, MARCH 24, 1970

HEW Secretary Robert H. Finch confirmed today he has urged the chief executives of the Nation's petroleum companies to work toward production of a lead-free gasoline for motor vehicles.

In letters to the executives mailed earlier this week, Secretary Finch said:

"The interestate nature of automobile use and fuel marketing demand a consistent national strategy for dealing with motor vehicle fuels in terms of reducing air pollution.

"In the administration's proposed amendments to the Clean Air Act, currently pending before Congress, we have requested that the Secretary of HEW be authorized to regulate the use of additives in motor vehicle fuels.

"I am hopeful, however, that progress can be made in advance of legislation."

Secretary Finch stressed that his objective is to provide motor vehicles with fuels which will help to ensure the greatest and most rapid reduction in air pollution at the lowest cost to the public.

The Secretary also asked for comments on a suggestion which would involve the marketing of low-lead "regular" gasoline from July 1, 1971 to July 1, 1974, and after that, an unleaded "regular" gasoline.

A leaded premium would continue to be marketed for cars which require high octane gasolines. Automobile manufacturers plan to market vehicles with low octane requirements in the near future.

Secretary Finch noted that a number of the petroleum companies have recognized the need to move toward unleaded fuels and many have recognized the need for Federal leadership in this area.

Copies of the Secretary's letter were also sent to automobile manufacturers and to the heads of companies producing lead additives.

As the President noted in his recent Message to Congress on the Environment, automobile manufacturers are preparing to market cars in the near future that are capable of using low-octane, unleaded fuels.

These manufacturers have stated that to meet the emission standards I intend to prescribe for the 1975 models they must have unleaded fuel. They have also stated that to meet interim Federal and California standards for nitrogen oxides, they must have at least a low-lead fuel.

A number of the petroleum companies have recognized the need to move toward unleaded fuels. Some have already announced plans or a willingness to make unleaded fuels available.

The interstate nature of automobile use and fuel marketing demands a consistent National strategy for dealing with motor vehicle fuels in terms of reducing air pollution. Many firms in the petroleum industry have recognized the need for Federal leadership. In the Administration's proposed amendments to the Clean Air Act, currently pending before the Congress, we have requested that the Secretary of HEW be authorized to regulate the use of additives in motor vehicle fuels.

I am hopeful, however, that progress can be made in advance of legislation. As the Cabinet official responsible for the Federal clean air program, I am writing to solicit your views on some of the unresolved questions—such as the timing of lead removal and the number and types of fuels to be marketed. In addition, I would welcome information on your present plans, resources, and problems.

In particular, I invite your comments on one suggested course of action that has been made:

1. After July 1, 1971, gasoline marketed in the United States would contain no more than 0.5 grams per gallon, of lead, unless its octane rating were at least 97;
2. After July 1, 1974, gasoline marketed in the United States would contain no lead unless its octane rating were at least 97;
3. Gasoline of 97 or greater octane levels would contain up to four grams per gallon, of lead, so long as the demand for such gasoline existed.

Such a course of action would encourage the marketing of low-lead and then unleaded "regular" grade gasoline which could meet the needs of approximately 60 percent of existing vehicles and an increasing percentage of vehicles as older cars are replaced by new ones with lower octane requirements.

I look forward to receiving your comments on the issues raised in this letter and any alternative proposals consistent with the objective of providing motor vehicles with fuels which will help to ensure the greatest and most rapid reduction in air pollution at the lowest possible cost to the public. I would appreciate a response by April 10.

Senator EAGLETON. Does any other Senator have an engagement compelling him to leave?

Senator DOLE. I have one at 10 o'clock, but I have no questions of the witnesses. Thank you.

Senator EAGLETON. I will go ahead, then, with a few questions I have, Mr. Tipton.

What is your opinion on whether the Federal Government should rely on the current theme of voluntary compliance and voluntary agreements with airlines with respect to emissions, contrasted with the Federal Government requiring the same by statute and implementing rules?

Mr. TIPTON. Our judgment is that the proposed legislation here which has the Federal Government setting down standards and providing for the enforcement of those standards is a sound principle. The airlines, I think, have done a good job in their voluntary program and will continue to do that, but in order to establish a nationwide standard and nationwide administration of those standards, we feel that legislation is necessary.

Senator EAGLETON. Does the current voluntary agreement between the airline industry and the Department of Health, Education, and

Welfare and the Department of Transportation eliminate the difficulty of differing standards in different States?

Mr. TIPTON. The present voluntary program does not eliminate the difficulty with different standards in different States. We would urge, as we have this morning, that legislation of the type before the committee be enacted in order to establish a nationwide standard and nationwide administration. That is our basic purpose for advocating this legislation, because, as I said, we really can't stand varying standards in varying States. The progress of this one transport airplane over 17 States in 1 day is as good an example of what we are talking about as could be suggested, and I might say that is not a particularly unusual day's operation for an airplane.

Senator EAGLETON. Referring once again to the voluntary agreement between the American domestic airline industry and the Department of Health, Education, and Welfare and the Department of Transportation, does this voluntary agreement unwittingly, perhaps, give a competitive advantage to foreign airlines that would not be part of such a voluntary agreement?

Mr. TIPTON. It inevitably gives a measure of competitive advantage if the foreign-flag airlines do not also carry out this same agreement, because to the extent that additional expense is caused to the American-flag carriers by making changes, to that extent you have a major competitive disadvantage on the American carrier's part.

Senator EAGLETON. In your prepared statement you talked about the enforcement and the implementation of any standards by the FAA. I do take it, though, from your statement that you recognize the fact that there has to be a governmental focus on the broad question of environment. Presumably that governmental focus will originate with HEW.

Mr. TIPTON. That was our judgment. This question of governmental operation, for this purpose we found a little difficulty because it was reasonably obvious that HEW was the agency which, as you said, had the overall responsibility for the measure to control air pollution. By the same token, if HEW were to take over the regulation even in part of our engine development, maintenance, and operation, we would have a very awkward regulatory situation.

So we tried to develop a line of demarcation between the agencies that would work and achieve the objectives that are sought and at the same time not produce conflicting regulations. Our line of demarcation which we recommend to you is that HEW establish the standards, that FAA then through its normal certification and regulatory process apply that to the aircraft engine. I think that would work.

Senator RANDOLPH. Mr. Chairman, could I interrupt your questioning?

Senator EAGLETON. Senator Randolph of West Virginia.

Senator RANDOLPH. Thank you, Mr. Chairman. The reason I do this is because there is a meeting of the Senate-House Conference on the postal pay legislation and it is necessary for me to go there. We are attempting to move forward in that matter.

Mr. Chairman, I have been a personal friend of Stuart Tipton for a long time. I recall very well when we worked years ago on the basic

Civil Aeronautics Act. At that time he was in the Federal service. Now he is the chief executive of the Air Transport Association, as we know, and is carrying forward important duties as President of the organization of the certificated airlines.

Mr. Chairman, I want the record to indicate that in Senate 3229, which basically you endorse, Mr. Tipton——

Mr. TIPTON. Yes.

Senator RANDOLPH. You point out very realistically the recommended changes. On page 6, I can understand your feeling with respect to the development, manufacture, operation, and maintenance of the engines that are used in the aircraft .operation. It is imperative that whatever we do here in 3229 in refining the legislation, it must reinforce its provisions. I am pleased that there are five of us within the subcommittee and the full committee who join with Senator Muskie in sponsoring this legislation, including Senator Eagleton who presides today. I am in complete agreement that whatever we do there must not be duplication and overlapping and conflict. You have indicated Mr. Tipton, that this could happen in the existing regulatory program.

You have stated that it should be clearly set forth that the responsibility between the Department of Health, Education, and Welfare and the Department of Transportation must be along lines that will be complementary rather than conflicting, and where there will be this partnership between these agencies of Government. That does not always occur in connection with the application of the provisions of such a measure to aircraft and their engines.

I am pleased that Senator Eagleton has pursued again the disparity that we find; namely, the foreign carriers not coming under the same pollution regulations as apply to the domestic carriers. When Secretary Volpe and FAA Administrator Shaffer were here, I also pursued that line of questioning at that time. I am sure that those of us who are interested in this type of legislation do realize that we are going to have more scheduled aircraft in the skies, not less. And we have, of course, the many general aviation planes that contribute to the congestion. I believe there are about 100,000 aircraft operating in the various catgories and it is estimated that the number will rise in the next 10 years to perhaps 120,000 to 160,000, and then it might taper off. But still there woud be some upward trend.

So, we are attempting to cope with a problem that will not diminish. Is that right, Mr. Tipton?

Mr. TIPTON. That is exactly right. There would be a very rapidly rising number of aircraft in operation throughout the United States and abroad.

Senator RANDOLPH. I agree with you that the aircraft industry is a responsible one. I was in it for 11 years and I think I came to that realization. It does have a duty not only to its passengers and to the shippers of the products that are carried in cargo of one type or another, and to the handling of the mails, but I think it has a responsibility to the mobility of our economy.

I do commend you and the air transport industry. In talking with those of your organization and you, sir, I come to the realization that the industry is, as you have said, ready to respond in this fight for cleaner air in which to fly your planes.

Mr. TIPTON. I do appreciate the comments that the Senator has made, particularly his reference to our long friendship, of which I am very proud, as well as his indication that he believes our industry is a responsible one. Thank you, sir.

Senator RANDOLPH. Thank you. That is all at the moment.

Thank you, Mr. Chairman.

Senator EAGLETON. Thank you, Senator Randolph.

One final question I would ask, Mr. Tipton:

It appears from previous testimony introduced at other hearings and including some before the Commerce Committee, that the culprit engine is the Pratt & Whitney engine that is used on the 727 and 737, and the DC-9, whereas the GE engine and the Rolls Royce engine are far less in the culprit category insofar as visible emissions are concerned.

Now my question is, did Pratt & Whitney engines win in industrial competition because it short-circuited pollution control?

Mr. TIPTON. I had never thought of that question before and, as you can see, I am having some trouble with it.

I would answer that no. The Pratt & Whitney engines have won in commercial competition because they were overall good engines and the smokiness or nonsmokiness of the engine, I think, had no bearing upon that Pratt & Whitney success. I would be reasonably clear in that answer because there are so many elements in the development and approval of an engine that one could really not identify that element as having a prevailing effect.

Senator EAGLETON. Let me put it another way: Would you admit to this possibility, that if there had been in the past 5 years the same focus of attention on emissions from jet aircraft that is prevalant today and if Pratt & Whitney had been required to develop an engine that was as relatively free of visible smoke emission as the GE and Rolls Royce engines, then isn't it certainly logical that the bid price of the Pratt & Whitney engines would have been higher than the price they did in fact submit. Thus, isn't the possibility that another competitive bid might have been a better bid?

Mr. TIPTON. I suppose that is a possibility, but I would also say that it is kind of an unlikely one. The price of engines, of course, it is quite relevant to their commercial success but even more relevant is the effectiveness of the engine. The price, again, is one element that is taken into account in the total determination to put a particular engine on a particular airplane.

Generally speaking, I would not give much weight in competition to this fact.

Senator EAGLETON. You are not saying, Mr. Tipton, that the price of pollution control equipment is inconsequential because that runs counter to the whole thrust of the testimony of the airline industry before they could not do this first by 1975, and then finally out of the goodness of their hearts they are going to do it by 1972, that this gigantic huge cost that they say they are going to pay in the public interest, millions and millions of dollars. What is it? Is it a cheap thing to do or is it an expensive thing to do?

Mr. TIPTON. This conversion is expensive.

Senator EAGLETON. If that had been built in the price of the engines when submitted to the various airline companies, it stands the test of reason that perhaps some of the airlines would not have bought Pratt & Whitney engines.

Mr. TIPTON. Comment on that, General.

Mr. VON KANN. Yes, if I may. I think there is a question of timing here, Actually, when the JT8–D engine was developed and designed, I don't recall that there was any particular competitor and this design period goes back many, many years, I would say a decade anyway, before there was any real concern about such things as smoke. As a matter of fact, just last August HEW itself was saying that the JT8 engine was not really a pollutant but that it had some undesirable esthetic characteristics.

The GE engines on the Convair 880's are not particularly smoke-free. The Rolls Royce engine, which is on the BAC–111, produces very little smoke but it is a later piece of technology.

I think once the requirement for relatively smoke free engines became evident to us and to the manufacturer, which was roughly about 5 years ago, then the new burner can was developed. But at the time I am not aware that there was any real competition between a relatively smokey and a relatively smoke-free engine.

Senator EAGLETON. Thank you very much.

I yield to Senator Hart.

Senator HART. I would like to comment only in one area and it does not have to do with visible smoke emission but obvious noise levels. What is your experience with the FAA noise control that is permitted under the Aviation Act? As I understand that act, the FAA can establish noise standards. What is happening?

Mr. TIPTON. The FAA has done so. After the statute was developed and passed, giving the FAA power to certificate engines on the basis of noise, after considerable study they developed a regulation. The regulation, needless to say, is a highly complicated one in view of the complexity of the aircraft itself, but in essence what it says is that an engine will not be certificated if it makes more than 108 pndb, which is of course a measure of the noise at various locations on the flight path sideline and approach.

The engines in future aircraft are required to meet that or not be certificated. That is the existing state of affairs under that statute.

Senator HART. Has any engine been ruled off the airlines?

Mr. TIPTON. Not yet. The engines in the 747 are the major newly certifiicated engines. They have been developed over the past few years. The effect of that development has been to produce about 2½ times the thrust of previous engines at less noise. I think that the concentration that has been imposed upon reducing noise in industry has produced what seems to me to be perfectly remarkable results in the development of the 747 engine. That engine and the airplane to which it is fitted have been certificated by the FAA. In the case of that engine, it does not at this point quite comply with the 108 pndb standard. It is required through engine changes and alterations to meet those requirements by the end of 1971.

Senator HART. How close do you understand the SST engine is to being within the 108?

Mr. TIPTON. I better ask Gen. Von Kann and Mr. Becker to comment on that.

Will you comment on that, Bill?

Mr. BECKER. Well, at the moment we don't have a very accurate understanding, I don't think anybody does. We do know that on takeoff, because of the power that will be in those engines and in the aircraft, which is needed at altitude to become supersonic, that they can when on takeoff, rise at a rapid rate; they have pretty much power. In the main, the distance between the listener and the airplane will be increased over what we have with our existing airplanes or even 747s. Therefore, it should be able to meet those kinds of noise levels on takeoff and on approach but we really don't know the answer yet.

Mr. VON KANN. If there is a problem, sir, with the Boeing SST, it would be with the sideline noise. Obviously they have several years ahead of them to work on this and they undoubtedly will be doing so. That would seem to be the most difficult area as far as meeting these standards.

Senator HART. Is my understanding correct, then, that the SST producer is on notice that he cannot make an engine with a noise level which exceeds 108?

Mr. VON KANN. The present rule does not apply specifically to supersonic aircraft. On the other hand, the manufacturer, as I understand it, is guided in his development work by the present rule. It is also my understanding that FAA will in due time publish a rule specifically referring to supersonic aircraft.

Senator HART. In terms of the audience, in terms of those of us who live on earth, what is the difference between noise damage or disturbance by supersonic aircraft and any other aircraft? If 108 is the limit we can absorb of an aircraft's noise, why are we being more tolerant of the supersonic aircraft?

Mr. VON KANN. I think that is a very good point, sir. It is my understanding that the manufacturer is aiming at the existing rule. I would imagine that future rules that would come out would be similar.

Mr. TIPTON. I would add to General Von Kann's point, I would think the the manufacturers of the SST would be required to approach the problem in just the sense that the Senator put it.

Senator HART. As the chairman of the committee, Senator Randolph, put it, we generally endorse the Muskie, et al., bill, and in that bill there is a noise pollution abatement clause and it establishes the HEW Office of Noise Abatement and Control.

This applies to vehicles egenerally and clearly to aircraft.

Do you see any conflict in the creation of an office of noise abatement and control, with the already established authority in the Federal Aviation Act, as amended, to establish an office of noise abatement control on the part of the Department of Transportation?

Mr. TIPTON. Our feeling on that is this: That there is not any necessary conflict between the two. The HEW activity would be one dealing with noise overall, and it would authorize extensive studies with respect to such noise. We have recommended strongly that the statute include the provisions which would require really quite close collaboration between the Department of Transportation and HEW and between NASA and HEW, because NASA has done——

Senator HART. Yes, you did?

Mr. TIPTON. Yes; we have not objected to the provision but we have asked that it be reviewed with the problem you raise in mind.

Senator HART. You mentioned that in your testimony.

Mr. TIPTON. Yes.

Senator HART. Thank you, Mr. Chairman.

Senator EAGLETON. Thank you, Senator Hart.

I wish to place in the record at this time so it may speak for itself—although it does not relate directly to the instant subject matter, I think it is one some bearing—an article in the Wednesday, March 25, 1970, edition of the New York Times on page 65, headline "Rolls Royce Steering Into Financing Woes," and in the article it describes its competition with Pratt & Whitney in some detail.

That will be made part of the record.

(The article referred to follows:)

[From the New York Times, Wednesday, Mar. 25, 1970]

ROLLS-ROYCE STEERING INTO FINANCING WOES

AEROSPACE AND AUTO COMPANY DROPPED BY STOCK INDEX

LONDON, March 24—Rolls-Royce, Ltd., embarrassed last year when its $20,000 automobiles in the United States were recalled to check for steering faults, has suffered a new indignity.

After 35 years, Rolls has been dropped as one of the component stocks in the 30-share industrial index compiled by The Financial Times. The big aerospace and automotive company has been replaced by a chain-stores group, Allied Suppliers.

A spokesman for the index, which is comparable to the Dow-Jones industrial average, said Rolls had been dropped "because it was felt that the company was no longer representative of the general trend of the market."

This delicately worded statement reflected the view of many London brokers that Rolls, once a top British bluechip issue, has turned into a speculative situation. The situation is that Rolls has run into problems financing the development of its advanced airplane engines. Another aspect is Rolls' association with the Lockheed Aircraft Corporation, which has problems of its own.

Over the last six months, the price of Rolls shares has dropped on news of reduced profits and dividends from $4.50 to $2.13. The share price, which hit a high of $6.60 in 1968, fell below the par value of $2.40 when the news of Lockheed's cash difficulties became known.

But the British company has been having cash problems of its own.

Rolls-Royce, best known perhaps for its expensive and prestigious automobiles, is only incidently in the auto business, producing about 2,000 cars a year. About 80 per cent of its $773-million sales in 1968 came from its Aeroengines divisions.

In 1968, Rolls scored a post-devaluation sales coup by winning a contract, thought to be worth billions of dollars, to supply its RB–211–22 jet engines for Lockheed's proposed airbus, the Tri-Star.

The British Government has given Rolls $113-million of the originally estimated $168-million development cost, and Rolls, beset by rising costs and other cash demands, is facing a potential cash squeeze until payments from Lockheed build up in late 1971.

To stay competitive with Pratt & Whitney and General Electric in the United States, Rolls has begun developing an advanced version of the engine, the RB–211–50, to power a longer-range version of the Tri-Star.

Rolls has gone back to the Government for additional financial aid for this project and is awaiting a decision. Market analysts estimate that, along with continuing and rising development costs on the first engine, the total development costs of the two engines could range up to $480-million.

Even if the Government is generous, it is expected by market analysts that Rolls will have to find about $200-million of its own money.

The sales outlook is not particularly encouraging, since Tri-Star orders have stagnated at only 180, when sales of perhaps 250 or more aircraft (each using three $2.5-million engines) would be needed to finance development costs.

Senator EAGLETON. Thank you, Mr. Tipton and gentlemen.

Mr. TIPTON. Thank you, Mr. Chairman and gentlemen.

Senator EAGLETON. Our next witness is Mr. Herbert L. Misch, vice president of the Ford Motor Co.

STATEMENT OF HERBERT L. MISCH, VICE PRESIDENT, FORD MOTOR CO.; ACCOMPANIED BY JAMES C. GAGLIARDI

Mr. MISCH. Mr. Chairman.

Senator EAGLETON. Good morning, Mr. Misch. You may proceed.

Senator HART. Mr. Chairman, may I introduce a very distinguished Michigan citizen who has the responsibility for developing an engine free of pollution. I suspect there are times when he and his colleagues in the automobile industry wish very much that they could tell the Members of Congress if we would stop hauling them down here to testify about what they are doing they would shorten appreciably the time within which they will develop this engine.

Mr. MISCH. Thank you, Senator Hart, but we are happy if we can help in your deliberations here. We are happy to be here.

I have with me, Mr. James Gagliardi of our research organization, who will aid me with some charts and possibly I may ask him to answer some technical questions.

I would like to start with my statement, if I may. It will be directed entirely to the area of vehicle emission controls.

The amendments on which I would like to comment are incorporated in two bills now being considered. These are:

S. 3229, introduced by the chairman of this committee in December 1969, plus amendment 501 introduced by Senator Montoya, designed to curb emissions from all moving sources of pollution; and S. 3466, introduced by Senator Scott to carry out certain proposals in President Nixon's environmental quality message.

Before I state the position of Ford Motor Co. on each of these proposals, I should like to say that our company fully supports the goal of insuring the quality of our atmosphere. We believe that clean air is everybody's business; and we are making it a basic aim of our business to contribute to clean air for everybody.

Let us then look at each of these bills separately.

First, S. 3229.

Section 103 of this bill proposes the expenditure of considerable sums of money for programs designed to develop low emission power sources. As members of this committee know, Ford Motor Co has been exploring alternatives to the internal combustion engine for a number of years. Although based on our research we believe that the best and quickest way to solve the vehicle emissions problem is to continue improving the internal combustion engine, we believe that a continuing comprehensive research effort is also important. Therefore, we support those provisions of S. 3229 that provide for Government participation in alternate power-source research, and pledge our cooperation with any such research program.

We endorse government participation in alternate power source research for three reasons: First, because chances of success of alternate power sources are slight in our opinion, and such research may not be sufficiently attractive to obtain the widest possible response from the private sector; second, because it is always possible that a fresh look at the problem could lead to new approaches that the automobile industry has not been able to develop; and, third, because even if such research does not produce new approaches, it would at least provide an objective demonstration of the need to rely on the internal combustion engine and to concentrate on its development.

Turning now to the language of section 202(a) of S. 3229, concerning a "manufacturer's warranty," we feel that if a warranty of parts is meant by this language, we are already providing it. If a warranty of extended emission control performance is required, though we feel the concept is desirable, there are practical problems that we consider insurmountable at this time and which may well become more insurmountable as emission control continues. And, finally, if by the term "warranty" the committee is seeking to concentrate on an end—lower emissions—rather than a particular means to gain that end, then we believe we can suggest a practical means that does not involve the very real difficulties involved in an extended performance warranty.

Before I describe such difficulties, I would like the record to show that we are not introducing objections because we are in disagreement with the purpose of this section. Not at all. We want a system that works, and we are working with increasing success to provide such a system. Our objection stems from the fact that an extended performance warranty, however laudable in concept, is not workable in the real world of fact. Permit me to elaborate by citing a few of many factors: Test complexity, the intermixing of manufacturer-car owner responsibility; normal probability, and the fact that real focus of the emission problem lies outside the scope of the warranty concept. I will discuss each of these factors in turn.

Text complexity.—We have found, often to our dismay, that emission control test results are a function of two factors: The State of the emission control devices and the state of the tests themselves. There is, gentlemen, unfortunately no litmus paper that one can slip into an exhaust pipe to produce an instant and inexpensive analysis of emission level and constituents. The test is complex, the equipment required is sophisticated and very costly, the skills required for the testers are exacting and still in the state of refinement. Today, one test for exhaust emission control alone takes 13 hours, and that includes computerized results. A short version of that test, known as a single cycle, seven-mode hot start test has some statistical validity, but because of variables in the way a car was driven just prior to that "quick" test, the test results cannot conclusively point to a repeatable "pass" or "fail" mark for any given car.

Last week in California at a meeting of the air resources board there was testimony from three sources showing that the minimum cost per test of the short—not the long—version was $35. Thus, a before and after test sequence would involve significant cost—and the results could be of dubious validity. Further, testing problems increase significantly as advances in emission control technology produce the substantially lower levels of emissions we envisage.

Intermixing of manufacturer-car owner responsibility: Though we fully accept our responsibility to design and manufacture our vehicles to meet emission standards and not fail because of faulty materials or workmanship for a reasonable time and distance, we cannot be certain that each individual driver will cooperate in maintaining those standards. Hence, we do not feel it to be reasonable or realistic to require the manufacturer to warrant against malfunctions produced by action or inaction by vehicle owners, such as damage, disconnection, maladjustment or neglect of necessary or normal maintenance. For example, neglect of servicing the positive crankcase ventilation valve, improper setting of the carburetor, use of improper fuel, fouled spark plugs, all affect the level of emissions, and all fall into the area of owner responsibility. Within this kind of environment, it would be most inappropriate to hold the manufacturer responsible for vehicles not meeting emission performance standards after periods of field usage.

Normal Probability.—In a vehicle population numbering many tens of millions, it is not abnormal for tests to show that some vehicles are not meeting the standards. Indeed, given the mathematical laws of distribution and probability, it would be abnormal to find anything else. Variations from the norm can result for any of a number of reasons involving normal variations in use, maintenance, and production. In fact, vehicles without emission control devices show an even greater range of emission variation. This variation has a critical and basic relationship to a functional warranty, since the warranty would be based on individual units. The level of emissions in the atmosphere, however, is meaningful only in terms of overall averages. In view of this, I would suggest that it is the pattern of deviation from standards that is important, not an individual instance. And such a pattern can be determined because the results of any series independent tests, given a large enough sample, will tend to occur in a pattern or statistical distribution. I would also suggest that it is the pattern for the older emission controlled vehicles that would be more significant for air quality than that of newer vehicles under warranty. A statistical sampling of the 20 to 30 million such older emission controlled cars could provide highly significant data on the actual effects of automotive emissions on overall air quality. The pattern thus determined, if found to deviate significantly from standards, could be affected by two kinds of action, taken separately or in concert.

If the pattern of emissions were found to be too high for good air quality, standards could be revised; or new requirements for emission control maintenance and inspection could be developed. This procedure would place the emphasis where it belongs, on what is actually happening in the real world of cars on our streets, rather than on what could result in a proliferation of minor adjustments with no real impact on the quality of air.

There are other practical considerations that I could cite also, such as the fact that unlike other malfunctions in which a customer would invoke a warranty, emission problems are basically silent and unseen. They do not manifest themselves in a manner that ordinarily would cause the owner to seek a remedy.

In view of these practical problems, and the existence of a better means of achieving the end we all seek, any mandate to invoke warranty requirements, though laudable in concept, would be illusory in effect. Therefore, we favor deleting this requirement entirely. However, since we already do provide a standard warranty covering emission control devices, should the committee still wish to include a warranty provision in the bill, we would suggest that instead of directing the Secretary of Health, Education, and Welfare to require such a warranty, that the language be changed to give him authority to do so should such a need be demonstrated and at such time as the present technical obstacles I have cited are overcome.

I would now like to address myself to a second item of proposed legislation, the administration bill introduced by Senator Scott.

S. 3466:

One of the most important provisions of this proposed legislation is contained in section 206 of S. 3466 and relates to the testing and certification of our new vehicles in respect to emission controls. For the first time certification through testing of prototype vehicles becomes mandatory for automobile manufacturers. This is not in itself a major change since as far as we know, every automobile manufacturer has utilized this optional certification procedure since the advent of controls in 1968. However, there is a requirement that a representative sample be tested as they come off the production line. We have no objection to this concept, feeling that it is logical and appropriate.

The proposed bill also gives the Secretary of Health, Education, and Welfare authority to revoke an automobile manufacturer's certificate of compliance if he finds a representative sample of vehicles on the production line does not meet the standards. We do not object to the certification method; we do not object to the sampling requirement; and we do not object to the proposed revocation of certification procedure. We do, however, object to the fact that such revocation will then call into effect the full range of "prohibited acts" listed in section 203 of the Clean Air Act. One such prohibited act, we believe, goes far beyond the requirements of this section of S. 3466. I refer specifically to the requirement that "manufacture for sale" cease upon revocation of certification. We do not feel that production should cease in order to remedy whatever defects may be found through sampling. Release of defective vehicles should cease, certainly. This we accept as a reasonable requirement during the time that corrective action would proceed. But halting production would not aid compliance, and, indeed, would make it more difficult to insure corrections under a normal production environment. I would, therefore, suggest that there be a change in the language to permit continued manufacture after revocation of the certificate, but prohibit sale or delivery of the vehicles so manufactured, until they met the standards.

Senator Dole. Could I interrupt briefly?

Senator Eagleton. Senator Dole.

Senator Dole. I just wanted to say that as long as we prohibit the sale of the defective vehicle it should not be necessary to stop production. The suggestion that you have made in your statement is very reasonable.

Mr. Misch. Thank you.

Section 210 of the proposed legislation and amendment 501 to

S. 3229 give the Secretary of Health, Education, and Welfare the authority to establish regulations on fuel composition and to control additives.

To assist in your consideration of this provision of the bill, I would like to emphasize the important role played by fuel composition in our effort to meet increasingly stringent Government emission control requirements.

As we concentrate on ways to reduce pollutants from internal combustion engines, I think it well to reflect that the enormous growth of efficiency of the internal combustion engine during the past eight decades would not have been possible without the concurrent development by the petroleum and associated industries of increasingly sophisticated fuels. Improvement in combustion chamber designs and higher compression ratios produced higher levels of efficiency and greater horsepower. Such improvements required higher octane antiknock gasolines and improved refining processes.

It is a tribute to the petroleum industry that it responded successfully to these challenges, and that quality fuel at reasonable prices has consistently been made available in abundance to keep in step with, and to support, the levels of efficiency and performance demanded of the internal combustion engine.

Today the petroleum industry and the automobile industry jointly face a new, and in some ways, more difficult challenge; to develop the right combination of fuel and engine conducive to virtual elimination of vehicle emissions. This problem has many difficult aspects, perhaps the most serious resulting from the existence of lead additives in gasoline. As a matter of fact, we are convinced that control of this additive is essential if we are to meet future emissions standards.

Let me tell you why we have reached this conclusion.

As a result of our research into methods of reducing vehicle emissions, Ford has studied closely the effect of lead as a fuel additive. There is one primary purpose for this additive—to provide an economical basis for achieving a high octane level in gasoline. While this is a positive contribution to engine efficiency and fuel economy, our emission control research has shown that there are a number of effects of lead in fuel that can only be considered as negative.

These negative effects involve:

Emission of lead itself in the atmosphere in the form of particulates.

Engine deposits which affect the overall level of exhaust emissions.

Barriers to the creation of three separate future emission control systems.

These latter three systems include two alternate methods for the control of hydrocarbon and carbon monoxide emissions as well as various methods being employed to effect actual recirculation of a portion of the engine's exhaust gases back into the engine to mitigate the formation of a third constituent, the oxides of nitrogen.

Let us look at each of these negative effects in turn.

Particulars.—Lead in gasoline is emitted into the atmosphere as particulate matter. While we are not qualified to address ourselves to the health danger, if any, that may be posed by these particulates, we do know that these small particles in the atmosphere can serve as nucleation centers so that smog aerosols, which hinder visibility and cause some eye irritation, can form and grow. Proposed Government standards of levels of 0.1 grams per mile in 1975 and eventual control to 0.03 grams per mile for particulates have been suggested by the Department of Health, Education, and Welfare.

Although formal test procedures have not as yet been established for measuring particulates, the limited number of tests we have conducted seems to indicate that the mass of particulates from a vehicle can be reduced by at least 80 percent just by changing from a leaded to a nonleaded fuel.

Engine deposits.—Studies have shown that for the engine itself, lead additives and their associated combustion chamber deposits have a significant effect on the deterioration of hydrocarbon emission control with mileage accumulation.

Let us look at figure 1 where we see the results of a Ford research study reported to the Society of Automotive Engineers in January 1967.

As you see, four vehicles were run for a distance of 24,000 miles. Two used Indolene 30 fuel—which contains 3 milliliters of lead per gallon—and two ran on Indolene clear fuel, which contain but 0.05 milliliters of lead per gallon, and is therefore considered essentially lead free.

The average difference in hydrocarbon emission levels between these two groups of cars is dramatic: 156 parts per million at the 24,000-mile point.

It should be pointed out that there was some criticism of the research findings reflected in this figure due to the test track mileage accumulation schedule that was employed, even though this was similar to the Government required method for mileage accumulation for certification of our vehicles.

In 1969, at another SAE Engineering Congress, Ford again presented data on similar vehicles as used in the 1967 work. This time, however, the vehicles were operated under random mileage accumulation. Again, the difference in exhaust hydrocarbon emissions between vehicles operated on leaded and unleaded fuels was significant (150 p.p.m.). The test results from both the 1967 and 1969 work are shown in figure 2.

These findings by Ford and conflicting reports by other researchers prompted formation of a joint automotive-petroleum-Government study panel. This study is being conducted under the auspices of the Air Pollution Research Advisory Committee (APRAC) of the Coordinating Research Council. We are confident that when this full report is available, by far most of research data submitted to this panel will agree with Ford findings concerning the relationship between presence of lead and magnitude of hydrocarbon emissions. Such base-engine hydrocarbon variations due to the presence of lead additives are particularly significant as the emission control requirements per car approach very low absolute levels.

Next, I would like to describe how lead additives have a highly deleterious effect upon three separate control systems designed to satisfy emerging emission control requirements. Let us direct our attention to these systems: exhaust gas recirculation, catalysts, and thermal reactors.

Exhaust gas recirculation.—Exhaust gas recirculation systems nominally involve controlled metering and cooling of exhaust gases before their entry into the engine induction system. The purpose is to lower peak combustion temperatures and thereby mitigate oxide of nitrogen formation. In order to avoid excessive mixture temperatures, the recirculated exhaust gases are normally cooled to approximately 250°F. to 300°F. However, since the majority of lead and compounds condense at temperatures above 500° F., lead deposits are formed in the exhaust gas recirculation system. These deposits can greatly affect flow characteristics by changing critical dimensions or by preventing individual components from functioning properly and reliably. The effects on system efficiency can be significant as shown in figure 3 for a very limited fleet of cars equipped with exhaust gas recirculation systems. The average control efficiency of vehicles on leaded fuel shows a rapid deterioration in only 6,000 miles of operation, while the unleaded fuel exhibits only small reduction in control efficiency.

Similar results have been observed in our engine dynamometer testing where with leaded fuels it often becomes necessary to stop and clean the exhaust gas passages in order to maintain the prescribed recirculation rates.

Catalysts.—Catalysts were first considered for vehicle emission control systems in the middle 1950's. Experiments were discouraging, to large degree, due to the fact that we could not discover a catalyst with sufficient life with leaded fuel. Although this was disheartening, we nonetheless continued our research. We did so because catalysts offer great possibilities for emission control. This is so since, through the catalysts, we cannot only reduce carbon monoxide and hydrocarbons but also cause selective reductions in those hydrocarbon compounds which are high in photochemical reactivity.

Recent studies show vividly the detrimental effect of lead on catalyst efficiency. As shown in figure 4, the catalyst tested could be expected to deteriorate to one-half its original efficiency by 7,500 miles with leaded fuel compared to 33,000 miles for the unleaded fuel.

I would like to interject at this point that we are continuing our catalyst studies with gasolines containing low lead levels; for example, 0.5 cubic centimeter of lead per gallon. These studies are being conducted with and without the scavenging agents normally used with tetraethyl lead (TEL). It is postulated that certain compounds formed by the lead and its scavenging agents play a significant role in the deterioration of catalysts. If our studies prove that catalyst life with 0.5 cubic centimeter/gallon TEL without scavengers shows promise, we think retention of this very small amount of lead should be considered as an interim step. Even retaining 0.5 centimeter per gallon of lead would reduce vehicular particulate emissions by about two-thirds compared to present levels. In addition, the octane benefit of this first 0.5 cubic centimeter per gallon is about 2½ to 3 research octane numbers, and thus facilitates a more orderly increase in the petroleum industry's refining capability to provide the octane improvement now accomplished by using much larger amounts of lead.

Finally, we have limited data to show that retaining 0.5 cubic centimeter per gallon of lead will mitigate the potentially serious engine problems for older cars which would occur should they be required to run on totally unleaded fuels. Figure 5 shows the effect of various lead levels on the horsepower of a new engine. We measure horsepower on this test, not because this is our major concern, but because horsepower is a useful variable to indicate the amount of "valve seat pound-in" that occurs during a severe test that is a routine part of our engine prove-out procedure. The figure clearly indicates that complete removal of TEL, or even the retention of TEL at the levels of 0.1 and 0.25 cubic centimeters per gallon will cause a serious deterioration of an engine's ability to function.

We are confident that we can design new engines to avoid this but for the millions of existing engines, retention of 0.5 cubic centimeter per gallon appears to be the best method of protecting the motorist until other means are found to avoid or mitigate this potentially serious "valve seat pound-in" problem.

We certainly hope that this can be solved by advancing technology because there is a strong possibility that total lead removal may be necessary for new cars by the 1974–75 era if our research indicates that even very low levels of lead are not compatible with catalysts. At the same time, we recognize that our engine problems are but one element of the overall equation, and that our technological development may have to yield—or at least be influenced—by other considerations. One such condsideration is the fact that the State of California is moving rapidly with action which could require one fuel having a research octane of not less than 90 with 0.5 cubic centimeter per gallon of lead in 1971, and a 90 research octane lead-free fuel in 1974. Another consideration could be the Federal requirements on particulate emissions.

Thermal reactors.—Still another way that appears to offer promise in achieving future exhaust emission standards is through use of thermal reactors. However, as with the catalyst, thermal reactors are susceptible to lead attack or perhaps corrosion from lead scavengers—chlorine and bromine. Figure 6 shows specimen losses after 50 hours exposure due to various fuels and temperatures.

The precise mechanism of how TEL, and sulfur and phosphorus, affects the corrosion resistance of these materials is not fully understood. However, the rate of corrosion with all leaded fuels is much faster than with unleaded fuel.

We must use high-alloy materials in these thermal reactors to withstand the high temperatures required to achieve our emission objectives. Additionally, these materials must be thin, typically 0.030 inch to 0.050 inch, to achieve these high temperatures quickly after vehicle startup. Therefore, corrosion rate of the materials is a very important design factor.

Elimination of lead would lessen the serious corrosion problems encountered with these high alloy metallic materials employed in thermal reactors. It would also allow further development of ceramic materials which today cannot be considered at all because of the deterioration produced by the presence of lead additives.

To summarize our position on the question of fuel composition, we feel that it is simply vital to continued progress in emission control that essentially all lead be removed from gasoline. We at Ford are doing what we can to emphasize the urgency of such action. We have made presentations to petroleum companies, we participate in an interindustry research program, we make relevant research findings public, and we have announced that we are providing engines capable of opertaing on essentially lead-free fuel—with a research octane number range of 90 to 91 and 0.5 cubic centimeter per gallon of lead—engines that will be compatible with the fuels that we believe the petroleum industry will have the capability of providing. This step alone has great economic importance to the petroleum industry because it will assure that by 1975 when essentially lead-free fuel will be absolutely essential to the advanced devices I have mentioned, perhaps as much as 40 percent of the total vehicle population will be able to operate an essentially lead-free fuel. Thus a significant market potential will exist for virtually lead-free fuel at such time as it is essential in 1975.

Contrast, if you will, the situation that would exist if the changeover to lead-free fuel were delayed until 1975. At that time, the petroleum industry would have a market made up of less that 10 percent of the vehicle population in the first year.

Mr. Chairman, we are aware that a job of major proportion faces the petroleum industry to produce a lead-free gasoline by 1975, for they do have a serious leadtime problem. My purpose today was to point out the essentiality of that action. Whether this is achieved by voluntary action by the petroleum industry or by authority in law in a judgment that the Congress must make. We would recommend, however, that some flexibility be provided in whatever method is decided upon, so as to allow optimization of the many factors involved.

Thank you.

(Charts accompanying Mr. Misch's statement follow:)

EFFECT OF COMBUSTION CHAMBER DEPOSIT ACCUMULATION ON EXHAUST HYDROCARBONS

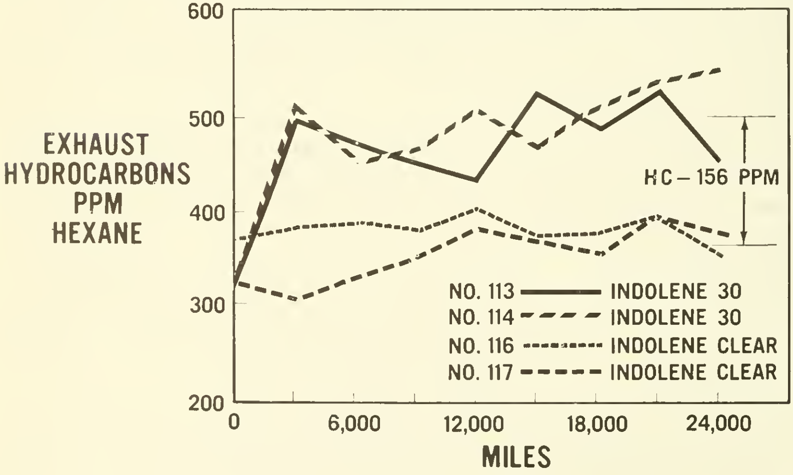


Figure 1

HYDROCARBON EMISSION DIFFERENCES DUE TO FUEL TYPE

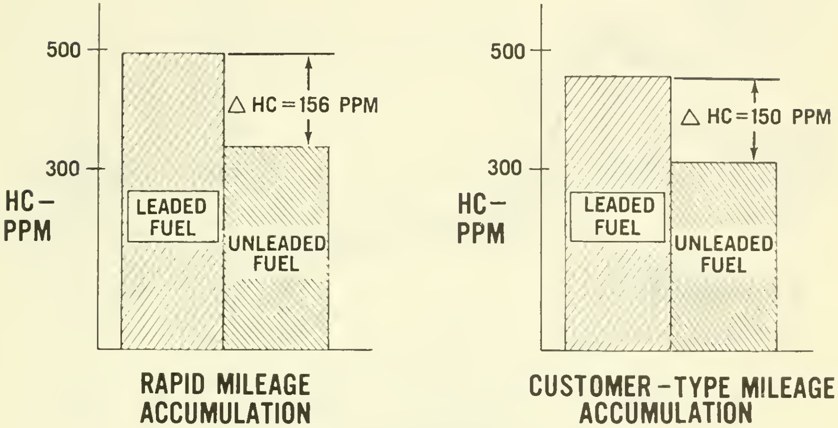


Figure 2

EFFECT OF LEADED FUEL ON THE CONTROL EFFICIENCY OF AIR CLEANER EGR SYSTEMS 302-CID 2-V AUTO GALAXIES

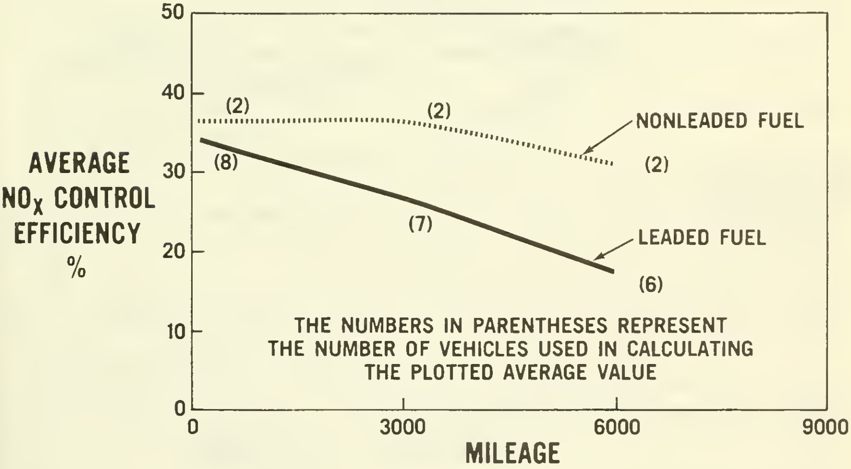


Figure 3

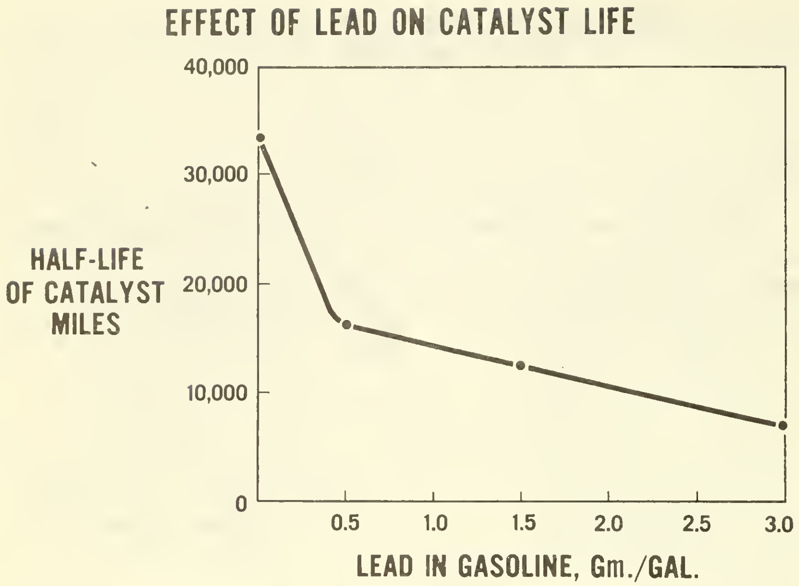


Figure 4

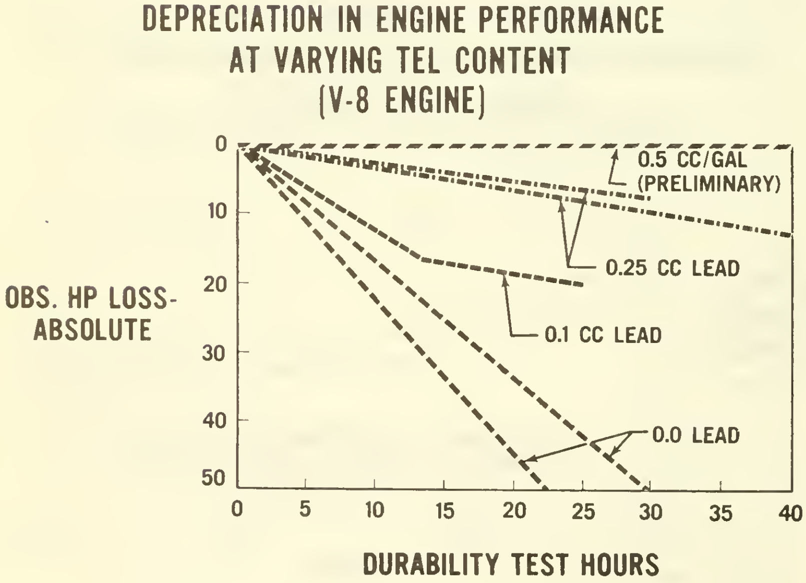
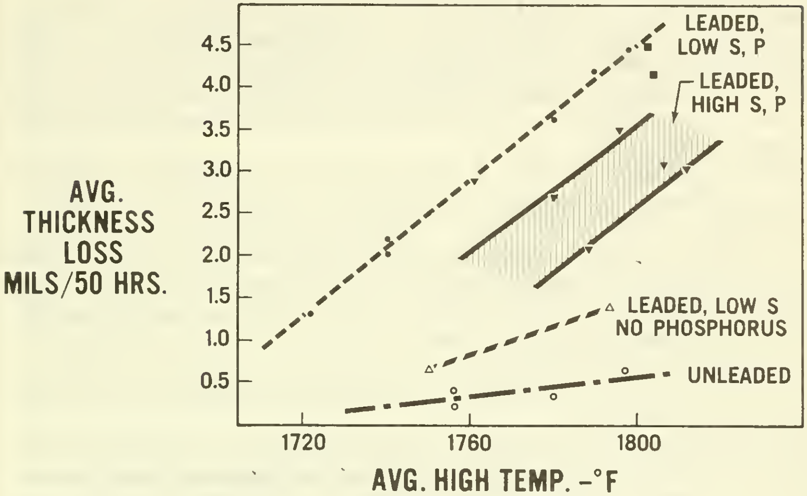


Figure 5



FUEL AND TEMPERATURE EFFECTS ON AVG. THICKNESS LOSSES OF SANDBLASTED OR-1 ALLOY SPECIMENS

Figure 6

Senator Eagleton. Thank you, Mr. Misch.

As you know, the Department of HEW in March of this year promulgated the new air quality criteria for carbon monoxide. In this material and in the specified so-called certain safe carbon monoxide levels for illustrated purposes pointed out that the city of Chicago exceeded the safe levels 30 percent of the time.

Now in light of those findings of criteria that have been established, I would like to ask these questions of you.

Will the increased efforts in control of new motor cars solve the problem soon enough?

Mr. Misch. Well, problems never can be solved soon enough. When we identify them we like to have them solved immediately. We think that great progress is being made with vehicles. As a matter of fact, at the levels for 1970, they are contributing greatly to reduction in overall carbon monoxide and the surveys that we have seen so far would indicate that great progress is being made. The more stringent standards to come will, of course, reduce the levels of carbon monoxide still further.

I would hope that, as indicated in my remarks, very careful surveillance of the ambient air quality in these critical areas would be maintained because over-control can be as negative with regard to our total populace as under-control.

The degree to which we control any one of these constituents that are important influences our ability to control the others. So we should not have more stringent controls on carbon monoxide than are in fact necessary to establish the quality required in the air. The same is true of the other constituents.

Senator EAGLETON. The standards to which I think you referred to would become operable in 1975?

Mr. MISCH. In 1975, naturally; yes.

Senator EAGLETON. Do we have the luxury of that amount of time?

Mr. MISCH. I think yes, when you see the reductions. We have gone over the hump as far as the increased population of vehicles is concerned. The increase in the total output of carbon monoxide now is overcome by the reduction in levels being emitted from the new cars. So we are coming down.

Senator EAGLETON. I take it then from your testimony that you believe the removal of lead would expedite this control proceeding.

Mr. MISCH. Well, it will have relatively little effect, as we see it, prior to 1974 in California or 1975 nationwide; but when we reach the point in time when we have to go to such devices as catalytic converter systems or high temperature reactors, then we will see additional reductions in carbon monoxide as well.

But up until the time the cars are equipped with those devices, I don't think we will necessarily see any major change due to the elimination of lead.

Senator EAGLETON. Let me phrase it another way: The elimination of lead and doing nothing else would have perhaps an innocuous or slight effect, but the elimination of lead in combination with other control techniques, would that be beneficial?

Mr. MISCH. Yes, sir.

Senator HART. Would the chairman permit a question here for my own understanding.

Additionally, would you say that unless we eliminate lead from the fuel, only modest improvement will result by the adoption of any known techniques?

Is that too strong a statement?

Mr. MISCH. Well, I would not want to commit that forevermore only modest improvement would be made.

Given enough time I guess anything can be developed but in this time frame we see no possibility without the removal of lead.

Senator EAGLETON. Would not the public be better served by the development of alternative combustion systems?

Mr. MISCH. Well, once again, certainly not in the time frame we are talking about. We have an urgent problem and we have to get the problem solved, and I think we are in the process of solving it and will take another major step in 1974, 1975. The alternate sources are not to be considered in that time frame.

Senator EAGLETON. What percentage of the gross revenues of the Ford Motor Co. are being spent on research and development of alternative combustion systems?

Mr. MISCH. We are spending about $28 million to $30 million annually in the area of emission control. This includes work on the internal combustion engine as well as alternate power sources. Our major effort——

Senator EAGLETON. What is your total gross?

Mr. MISCH. Our total gross sales?

Senator EAGLETON. Gross receipts, gross revenues before taxes?

Mr. MISCH. Well, our gross sales are about $14.7 billion.

Senator EAGLETON. And you cannot break down how much of that

$28 to $30 million out of the 14-some-odd-billion dollars is directed toward the development of a new type engine?

Mr. MISCH. Well, I am reluctant for this reason, because we have said publicly many times that we are putting by far the major portion of our research efforts on alternate sources into the gas turbine. For proprietary reasons I am reluctant to break it down any more to designate how much specifically we are doing. This is spending close to our hearts.

Senator EAGLETON. If you want to whisper it to me, I will keep it a secret.

Should this committee be considering nationwide standards for used motor vehicles already on the road?

Mr. MISCH. Well, we have a program going right now where we are cooperating with the General Services Administration to evaluate at Cape Kennedy in a fleet there what we might do with the used cars. Prospects are quite encouraging. We, as well as other members of our industry, have been working with fleets in California on ways to meet the used car provisions that are on the statutes in California. We have every intention and I believe most of the other manufacturers have every intention of meeting that, and of providing a used car kit.

I think that it would be appropriate to measure the success of these programs at least for the next year before considering application nationwide.

Senator EAGLETON. Should this committee consider granting specific legislative authority to the 50-some-odd-air-quality regions giving those regions authority to prohibit outmoded transportation if they think such is warranted in the interest of the health of that region?

Mr. MISCH. I have not thought of the question before. I am assuming that you are saying that the air quality standards are established federally and that ——

Senator EAGLETON. Criteria.

Mr. MISCH. Criteria. How about the standards?

Senator EAGLETON. The standards are approved by the Federal Government after public hearings, the individual implementation plan is filed at the public hearings in the region and then pursuant to that plan, specific legislative authority could be given to restrict automotive transportation in that region depending on atmospheric conditions, environmental conditions, and for any other public health reason.

Mr. MISCH. Obviously we don't like to see that sort of authority vested in such a manner that it would consider only one element of the total system, namely, air pollution, and not the necessity for the economic viability of the community as well if they need a transportation system. If the authority was so placed that it would be exercised only when necessary to control the environment, I think we would be in favor of it.

Senator EAGLETON. Of course health has to be considered first because the economic viability of a dead community would not mean much.

Mr. MISCH. Not if it was a dead community; that is right.

Senator EAGLETON. My final question: In March of this year, the Department of Health, Education, and Welfare issued a report revealing that in the city of Chicago safe levels of pollution are exceeded 30 percent of the time. Can we offer any hope to the residents of Chicago and similar cities, for any immediate relief to the dangers that are inherent in exceeding those safe levels 30 percent of the time?

Mr. MISCH. I am not in a position to predict just what the air quality sampling will show a year from now or 2 years from now. I want to say this, that it would seem that carbon monoxide can only go down. I rationalize it this way:

In the congested areas where it is the greatest problem, I think we will all agree that traffic is practically bumper to bumper today so it is hard to believe that the population of vehicles in these congested areas is going to rise; as a matter of fact, it probably is going to stay pretty nearly the same. You cannot get more than a full line in.

On the basis that the vehicles we are producing are considerably lower in carbon monoxide emissions than the vehicles they will be replacing in the normal market, the prediction has to be that the levels of CO_2 are coming down. I think in many areas this has been proved by sample.

Senator EAGLETON. Senator Hart.

Senator HART. I recall examining the Ford display a few weeks ago. Are there any answers out of Cape Kennedy yet?

Mr. MISCH. Yes. It is preliminary but we are through about a third of the fleet as I recall, and it looks as if we can reduce the number of hydrocarbons and CO_2 about 50 percent as compared to what we find on the vehicles originally tested, and oxides and nitrogen are a little bit lower. They are not 50 percent lower, but they are lower.

Senator HART. How close does that come to the estimated 75 percent?

Mr. MISCH. Significantly ——

Senator HART. Significantly above?

Mr. MISCH. Yes.

Senator HART. Thank you.

Senator EAGLETON. Senator Dole.

Senator DOLE. In your statement you endorse Government participation in the search for alternate power sources. You also endorse section 103 of S. 3229.

That bill authorizes up to $200 million for the fiscal year ending June 30, 1973. That seems to me to be a lot of Federal participation. You outline of course three reasons why you feel Federal participation would be helpful. I wonder if a fourth would be that it would save your company money.

Mr. MISCH. Well, I think by and large the way we are thinking is that the Federal Government would want to involve others besides those in the automobile business in this activity. If we can provide a useful purpose, we would be happy to do so. I think that participation with the Government in some of these activities goes a long way toward making results believable, if you will.

Senator DOLE. Do you have any idea of the total research expenditures of the automobile industry on an annual basis?

Mr. MISCH. I am sorry, I don't. I don't know.

Senator DOLE. I was curious as to whether there was any relationship to the figures in section 103. I don't know how the figures were arrived at.

As I understand, you can't reveal what you spend on research.

Mr. MISCH. I can say this: this looks like a lot of money to us.

Senator DOLE. It seems like it is a lot of money to me too, maybe more than is needed, and more than can be used. I don't know, I am just trying to find out if we ought to take a look at section 103 and maybe reduce it or maybe expand it. There has been no testimony thus far that indicates how we can justify any of the figures.

Mr. Misch. Well, I think it would be a lot easier to evaluate the appropriateness of the expenditures when the programs themselves are developed. This may be an authorization to spend. There is a possibility that substantial programs could be developed without requiring this amount of money. I would not want to judge it before the programs were developed.

Senator Dole. Can you give us any idea of the amount of money expended by your company in this area? I am trying to find out from the different witnesses how much industry is doing and what the Federal Government should do. If you are spending $25 million a year or more, maybe the figure of $45 million for fiscal year ending June 30, 1970 is realistic and maybe the increase up to $175 million would be realistic by 1973. But if industry is spending a negligible amount, maybe they should contribute more and the Government less.

Mr. Misch. Well, it would seem that some of these amounts are high unless you consider that they are going to involve a number of redundant or duplicative activities. We as a company have spent many millions of dollars in arriving where we are on turbines, for instance, but it is over a long period of time. There is some question as to whether or not this amount of money could be spent appropriately and efficiently.

Senator Dole. I don't quarrel with your statement. My question is should we not at least make some effort to justify the expense to the taxpayers. At the present time everyone is concerned about pollution and pollution control. One way to dramatize that concern is to trot out a big figure which may be solace to some but does not necessarily solve the problem, and is our responsibility.

Now are you working on certain alternate sources, steam cars, and battery operated automobiles?

Mr. Misch. Our work is mostly on the turbine. Our work in steam power is primarily through an interest that we have in a company called Thermal Electron Corp., Waltham, Mass., who are working on the essentials of the Rankin cycle engine and cooperating with them as advisors and consultants on occasion. This keeps us, we think, adequately close to the state of the art but we are doing practically no work on steam in-house.

Senator Dole. You mentioned the difficulty of emission control tests. Can inspection programs and emission standards in fact reveal that we are achieving air pollution control with emission devices? Is that possible, or are we going to have to wait and observe whether ambient air quality standards are being met?

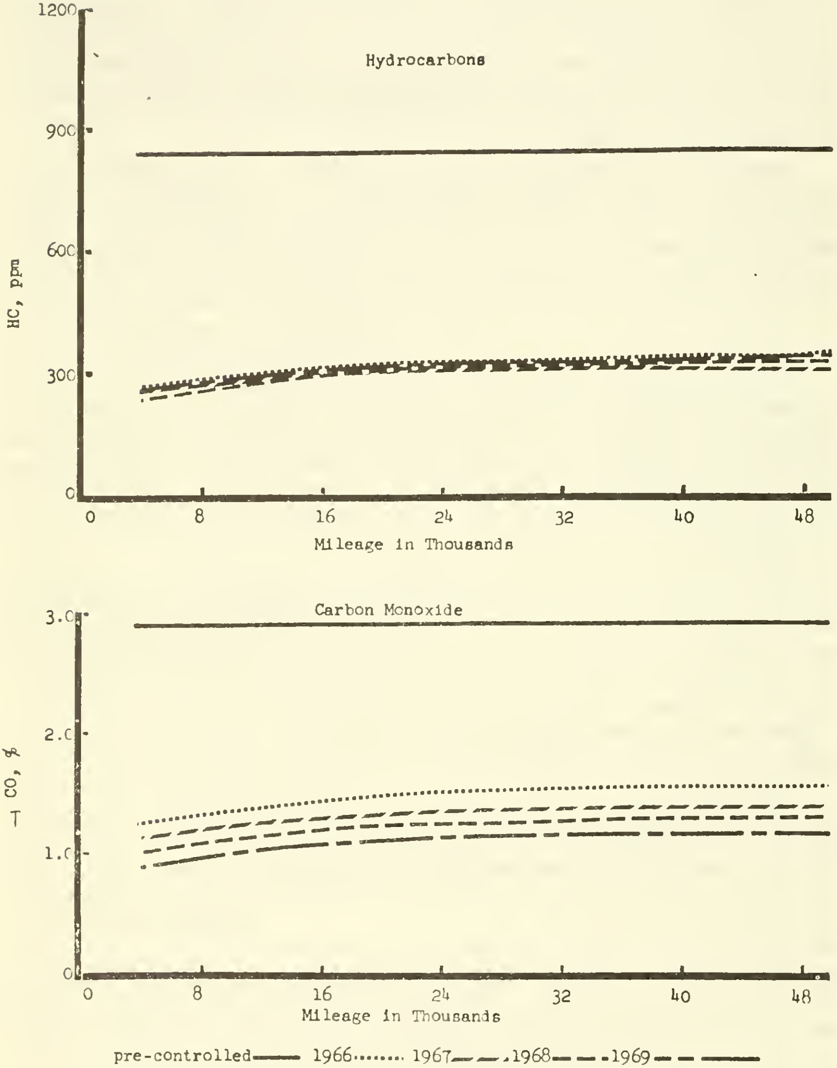
Mr. Misch. No; I think we can test them. I think through surveillance you could get representative samples in the field and determine what the effects are.

I think, if I may, I can answer that perhaps this way: I have some duplications of a reference from the California Air Resource Laboratory report on surveillance that might answer this question and it might be well to put it in the record, if I may.

Senator Eagleton. It will be made part of the record at this point.

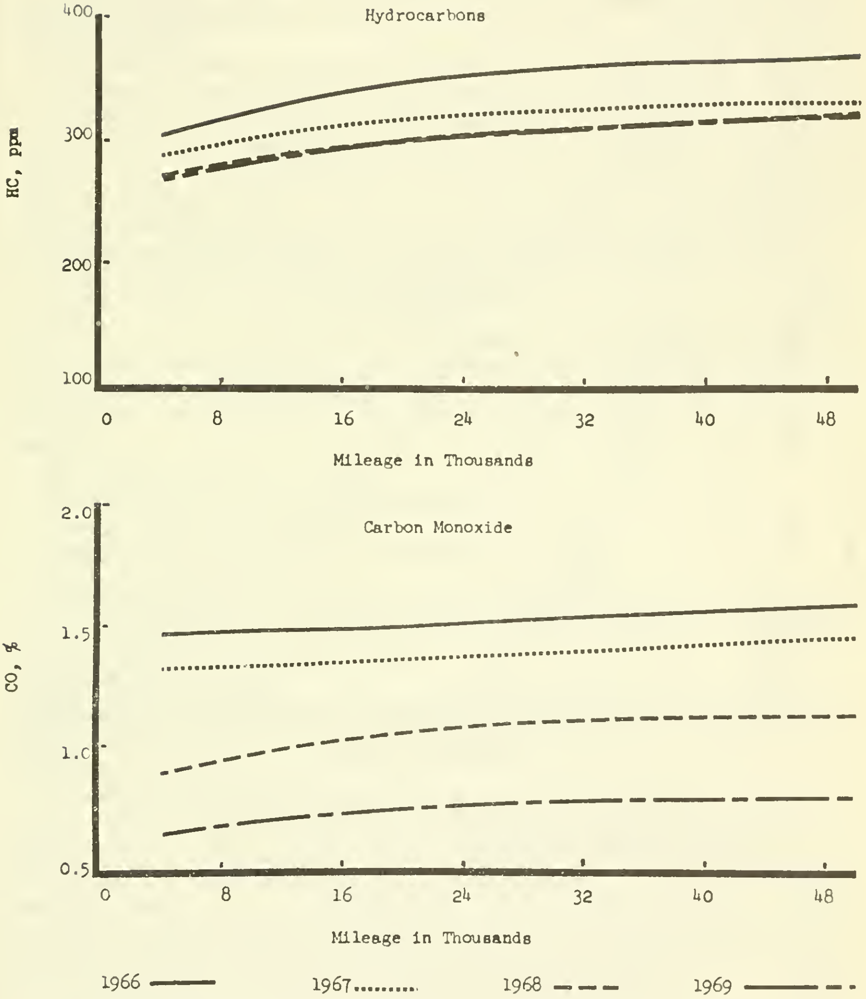
(The material follows:)

Figure 1. Exhaust Emissions vs. Mileage. California Automobile Population, comparing pre-controlled to 1966-1969 models.
Hot Start Data



Reference: California Air Resources Laboratory Report on Surveillance of Motor Vehicle Emissions in California, Supplement to Progress Report #17, February 6, 1970.

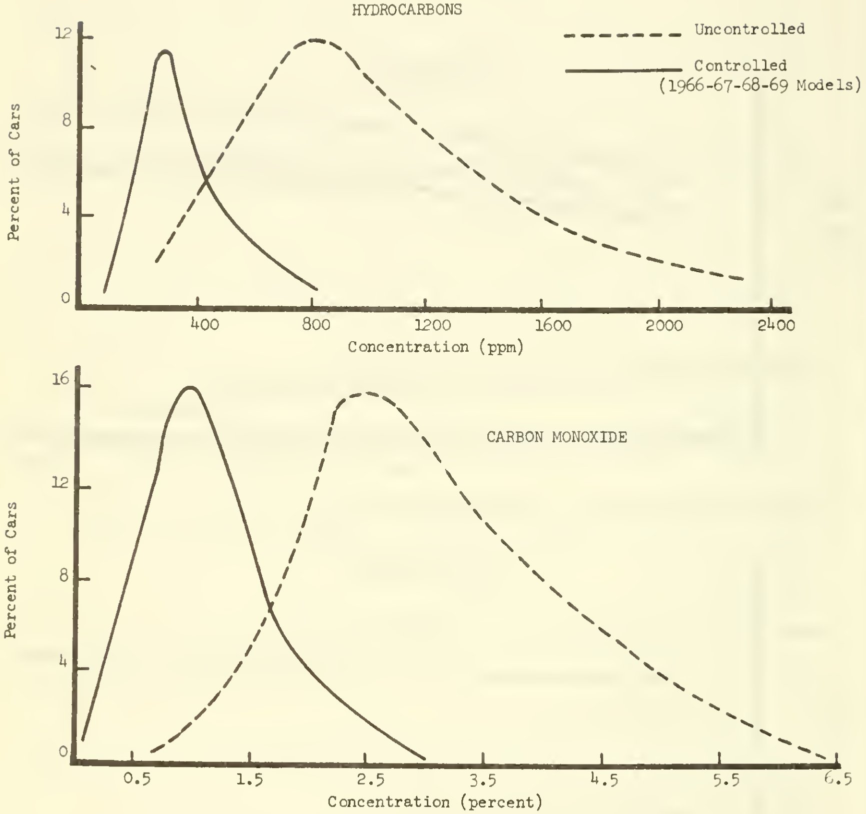
Figure 8. Exhaust Emissions vs. Mileage
1966-69 Ford Motors Automobiles
Data Corrected to Reflect California Population
All Tests Hot Start



Reference: California Air Resources Laboratory Report on Surveillance of Motor Vehicle Emissions in California, Supplement to Progress Report #17, February 6, 1970.

FIGURE 4

Distribution of Hydrocarbon and Carbon Monoxide Emissions
From Controlled and Uncontrolled Cars



Reference: Air Pollution Control in California, 1969 Annual Report - Air Resources Board, January, 1970.

Mr. MISCH. You may quickly want to look at these three charts. The first chart is for all automobiles, 1966 through 1969. It shows a number of hydrocarbons as an average in an uncontrolled condition as the line at the top and then, where all the makes of cars are on a controlled basis, shows a very substantial reduction already.

The lower chart shows a similar thing for carbon monoxide. You will note the year-to-year improvement in carbon monoxides from 1966 through 1969.

The second chart for Ford cars only shows the year-to-year improvements in both hydrocarbons and carbon monoxide.

The last chart illustrates the importance of averaging in that it shows the actual distributions of the samples tested, with the dotted portion being uncontrolled vehicles and the solid portion being controlled vehicles. Then it shows how the norm has been moved over. The 6,000 vehicles surveyed are customer operated vehicles. I think this is a good mechanism for determining in fact whether the controls are, in part, effective. I think this proves that they are working.

Senator DOLE. Then finally because we have other witnesses I share your view with reference to intermixing of the manufacturer and car owner responsibility. If the product meets the standards when it is sold and the equipment operates properly in accordance with the warranties and the standards set, then the responsibility must shift to the owner.

Mr. MISCH. That is correct.

Senator DOLE. So I would share that view.

Thank you, Mr. Chairman.

Senator EAGLETON. Thank you, Senator Dole.

Senator Hartke?

Senator HARTKE. The Department of Health, Education, and Welfare established the emission rules for 1975 and I am sure you are familiar with those; are you not?

Mr. MISCH. Yes, sir.

Senator HARTKE. Can the automobile industry meet the emission control standard as set by the Department of Health, Education, and Welfare by 1975?

Mr. MISCH. We don't honestly know. We are certainly trying. We are not discouraged at this moment. We have looked at the relationship of fuels to the systems we are working with, and unless we can anticipate the elimination of the corrosive effects of lead in our fuels, we don't think we can bring home the catalytic converter systems and high-temperature reactors that would be necessary for 1975.

Thus I cannot categorically say that we are going to meet 1975 requirements. We are going to make every effort to do so.

Senator HARTKE. The principal approach you are using is the removal of lead from gas, is that right?

Mr. MISCH. No, sir. That just allows us to consider certain approaches. Lead in the gasoline has such a deleterious effect on some of the devices that it virtually rules them out as being something that we could design and make effective.

Senator HARTKE. Let me ask this question then. Is it the intention of the automobile industry to attempt to meet these standards and these goals by the continuation of the use of the internal combustion engine?

Mr. MISCH. Yes, sir; it certainly is for my company.

Senator HARTKE. I think from what you have said it is a fair statement, then, that the ability even to reach these emission goals does depend on the removal of lead from gasoline. That is one of the factors and one of the main factors, is that correct?

Mr. MISCH. Yes, sir.

Senator HARTKE. Now then that does involve the use of a catalytic muffler, is that correct?

Mr. MISCH. That is one approach that we are looking at.

Senator HARTKE. Well, is that one of the major approaches?

Mr. MISCH. That is one of the major approaches.

Senator HARTKE. This will provide for a longer life of the muffler in case of removal of lead, is that correct?

Mr. MISCH. That is correct.

Senator HARTKE. How much will the removal of lead cost the American consumer?

Mr. MISCH. I don't think I can answer that question.

Senator HARTKE. Well, can you give us any idea at all? Isn't that a problem here? Isn't that a factor involved? I mean after all, we are concerned about what happens to the automobile industry, but there are more consumers than there are manufacturers and ultimately the question involved here is that if you are going to use an internal combustion engine which you say is your present intention and if you are going to even attempt to reach the goals by 1975, then isn't it a fair question to have you give the people who are going to be using those vehicles, the consumers, some ideas as to what it is going to cost them?

Mr. MISCH. Well, I can say this: It is our considered opinion that modifications of the internal combustion engine and its system, including modifications of fuel, will cost the consumer far less than any alternate source we have ever considered.

Senator HARTKE. How can you make such a statement if you say you don't know what it is going to cost the consumer? How can you say it is going to cost far less if you don't know what it is going to cost on either side? Do you have any estimates at all on either one of them?

Mr. MISCH. I have no estimates on the cost effect.

Senator HARTKE. How can you make such a categorical statement then to say that the cost to the consumer will be far less than any other system?

Mr. MISCH. That we have looked at, I said.

Senator HARTKE. Pardon me?

Mr. MISCH. Any other system that we have looked at.

Senator HARTKE. Any other system that you have looked at?

Mr. MISCH. Yes, sir.

Senator HARTKE. Can you give me any basis for that whatsoever?

Mr. MISCH. Well, one of the bases is this: We have, as an industry, announced that we are going to build our automobiles so that they will operate on lower octane fuel. This is for the purpose, we hope, of enabling the petroleum industry to supply a lead-free fuel at a lower cost.

Senator HARTKE. Is it the idea of the industry to maintain the present compression ratio?

Mr. MISCH. No, sir.

Senator HARTKE. In other words, you are going to lower the compression ratio, is that it?

Mr. MISCH. We will have to lower the compression ratio on many of our engines.

Senator HARTKE. Then there is the possibility that the removal of the lead may not cost the consumer any more, is that correct? Is that a fair assumption? Or is it going to cost him a little bit more or a whole lot more?

Mr. MISCH. It is probably going to cost him a little bit more because, as we use a lower octane fuel, he is going to use more fuel.

Senator HARTKE. In your opinion is it going to cost more to refine this new fuel?

Mr. MISCH. I am told that it is. I don't know of my own knowledge.

Senator HARTKE. Do you have any estimates how much that would be?

Mr. MISCH. No, I don't.

Senator HARTKE. In other words, we don't know what it is going to cost in increased use of fuel if we don't know what it is going to cost in increased use of the internal combustion engine if you use a nonleaded gasoline, is that correct?

Mr. MISCH. I can't qualify it today, that is right.

Senator HARTKE. Can you give us any idea on procurement costs as far as the consumer is concerned if you do reach the standard by 1975, what the cost per vehicle would be? Do you have any estimate at all?

Mr. MISCH. Our estimates are not accurate at this point.

Senator HARTKE. Estimates are not necessarily accurate, but they can be accurate estimates.

Mr. MISCH. Well, they are estimates of the laboratory prototype which are not the devices that we would ultimately be producing in production. We don't have a design for production yet and, therefore, it is difficult to be accurate in estimating costs. I have said before that it appears that these devices are going to cost in the neighborhood of $150 to $300.

Senator HARTKE. Per vehicle?

Mr. MISCH. Per vehicle.

Senator HARTKE. All right. Now what about maintenance costs? Can you give us an estimate of what the increase on maintenance cost would be?

Mr. MISCH. If we are successful with high-temperature reactors, the maintenance cost should be practically no greater than today. For catalyst systems it depends entirely upon the life that we are able to develop and, therefore, how frequently replacement would be required.

Senator HARTKE. I have here a letter by Henry Ford dated January 27, 1970, in which he said, and this was addressed to a number of major oil companies:

> I would also appreciate knowing how soon you think lead might be removed from premium grade fuel so we might again build new cars with more efficient engines requiring higher octane fuel.

Is that the intention?

Mr. MISCH. Yes, sir.

Senator HARTKE. You are going to use a higher octane fuel?

Mr. MISCH. When it is provided by the industry.

Senator HARTKE. There is no question, then, that that will make the price of fuel cost more; right?

Mr. MISCH. That would make the price of that fuel cost more; yes.

Senator HARTKE. Do you have any estimate of a 10-percent increase, 20 percent?

Mr. MISCH. I have no estimate.

Senator HARTKE. These devices that you are going to put on, you say as far as maintenance is concerned, that basically if they are developed properly it would not be higher, is that the word you use?

Mr. MISCH. I said if we are successful in using high-temperature reactors and successfully in developing the catalyst durability that we would want, then the maintenance would be very little higher.

Senator HARTKE. Would these devices have to be replaced periodically?

Mr. MISCH. The device would not. With a catalytic muffler as we see it today, the catalyst itself would have to be replaced.

Senator HARTKE. How much would that cost?

Mr. MISCH. I have such a wide range of numbers I don't think they would be useful.

Senator HARTKE. Can we get the wide range and then maybe have an interim?

Mr. MISCH. It depends whether it is a noble-metal catalyst or transition-metal catalyst, and I would say somewhere between $10 and $35.

Senator HARTKE. How often will that replacement have to be made?

Mr. MISCH. Our target is to have a catalyst that will operate for a minimum of 50,000 miles. We are not there yet but that is our target.

Senator HARTKE. Now if we put on these pollution control devices, will the States or the Federal Government have to establish inspection procedures in order to make sure that the consumer is replacing the elements of the pollution device which would have to be on the system to keep it working?

Mr. MISCH. I would think that some way of insuring that the user was contributing his portion to clear air would be necessary.

Senator HARTKE. Do you have any idea how much that will cost?

Mr. MISCH. The inspection system?

Senator HARTKE. Yes, on this type.

Mr. MISCH. I think it could be a very simple part of the normal inspection system in those States where they have one.

Senator HARTKE. It has been reliably reported on this line of questioning that it would cost the industry and the consumer a total of about $18 billion. Is that a fair estimate?

Mr. MISCH. I have no idea. I don't know.

Senator HARTKE. Would it not be cheaper in the long run to try to develop a nonpolluting engine that is inherently nonpolluting rather than to go ahead and modify the present system with all these "ifs" and "ands" and hypotheticals and undetermined factors?

Mr. MISCH. If we knew of an engine and if we knew how to develop it so that it could replace the transportation system of today in any successful way, I would agree.

There are a lot of "ifs" here too. A continuous combustion system, such as is used in the gas turbine, as is used in the Rankin system engine or is used in your hot water heater at home is not necessarily inherently free forevermore of emissions without proper adjustment, and so on.

Senator HARTKE. Would you give us an estimate maybe what it would cost to develop an inherently nonpolluting type of engine?

Mr. MISCH. We have spent well over $100 million in the development of gas turbines so far as we don't have one on the market yet.

Senator HARTKE. I will tell you what my fear is and it is just one Senator's fear, and that is that we might lead the public to believe that if we can somehow take the lead out of the gas, that we have accomplished successfully the nonpollution of the atmosphere.

Do you believe that if we just take the lead out of the gas that we will have successfully accomplished the purpose of nonpollution of the atmosphere?

Mr. MISCH. Absolutely not. Absolutely not. We make no contention that this is a fact. It is one step that appears to be required now. I hasten to say this: Our industry program—involving petroleum industry representatives as well as ourselves—includes a great deal of research work on devices that would be effective without removing lead from gasoline.

We have not given up yet. But if we are going to meet the 1975 standards, we can't bet on the relatively remote possibility of making these devices work with lead in the gasoline.

This is the point we are trying to make. We are not giving up.

Senator HARTKE. I think we have met the 1975 goal. I am not saying that doing the best you can, that you are expected to do better than you can, but I just think we have to meet the 1975 goal. I do not believe at the present time that the impression is being created that it is not going to be met.

I think the impression is left generally speaking from what I read and what I hear that if somehow or another you can just take the lead out of gasoline, that that will solve all of this problem, sort of a self-deceiving type of operation, an illusion of success rather than realistically coming to grips with the heart of the problem.

Mr. MISCH. I would hope, sir, that my total statement does not make this point. I have tried to make clear that, even with lead out of gasoline, we don't yet know how to get adequate life on catalytic converters. We have more work to do there.

Senator HARTKE. I think you ought to come up with some realistic estimates on the cost which, as I understand, is in the neighborhood of $18 billion; $18 billion, and you say you are spending $100 million. There is a thousand million in a billion.

It gives you a little idea of what concepts are involved.

All right.

Senator EAGLETON. Before yielding to Senator Spong, this committee is going to get the lead out of these hearings and I am going to ask the next three witnesses when they are called to summarize their statements for us and their full statements will be printed in the record.

Senator Spong of Virginia?

Senator SPONG. Mr. Chairman, I apologize for not being here when the hearing opened. I only have one brief question which touches upon one of Senator Hartke's last questions.

Would a change from lead into an unleaded gasoline increase the photochemical smog reactivity? Does your research tell you anythong about that?

Mr. MISCH. Well, it is a rather complex question.

Senator SPONG. I know.

Mr. MISCH. We have to assume what will happen in taking the lead out of fuel. Taking the lead out of fuel and at the same time requiring octane values for the total spectrum of fuel would necessitate additional refining, reforming processes and so on which would increase the aromatic portions of the fuel.

I don't know the degree to which this would have an influence on photochemical smog. I am not hedging at this point. The devices we expect to use to meet the 1975 level of national emissions requirements, such as catalysts, are very good in selectively eliminating the aromatics that might be of concern. However, for those vehicles not having a catalyst or something like that, I am sure the aromatics would increase.

Senator SPONG. Thank you.

Thank you, Mr. Chairman.

Senator EAGLETON. Thank you, Senator.

Thank you very much, Mr. Misch. We appreciate it.

Mr. MISCH. Thank you.

Senator EAGLETON. Our next witness is Mr. Lawrence E. Blanchard, executive vice president of the Ethyl Corp.

Would you identify the gentlemen accompanying you for the record.

If it is possible to summarize your statement, we would appreciate it. Your full statement will be made a part of the record.

Senator SPONG. Mr. Chairman, I might say before Mr. Blanchard begins that placing him, on a time limitation and asking him to summarize his statement might be something of a burden for him.

Senator EAGLETON. We do not want to overly burden you.

STATEMENT OF LAWRENCE E. BLANCHARD, JR., EXECUTIVE VICE PRESIDENT, ETHYL CORP., ACCOMPANIED BY HOWARD E. HESSELBERG, COORDINATOR OF AIR CONSERVATION, AND DANIEL A. HIRSCHLER, DIRECTOR OF AUTOMOTIVE RESEARCH

Mr. BLANCHARD. I should say I am an ex-lawyer; I claim to be a finance man now. I can try to summarize my statement but it is not an easy one of this much importance from our standpoint.

My name is Lawrence E. Blanchard, Jr., and I am a resident of Richmond, Va. I hasten to add that I am no expert, I have never been before the Senate before. I did not realize how complicated it was to get all the experts to agree on every word I wrote in a speech, but I do want to say that with those first two sentences in here, no expert has been able to disagree with so far.

I am executive vice president of Ethyl Corp. which 47 years ago introduced into commercial use the gasoline additive known as lead antiknock compound, or "tetraethyllead," now an essential component of 98 percent of all motor gasoline made in the United States. With me today are two gentlemen with many years' experience in the technical aspects of automotive emissions control, Howard E. Hesselberg, our coordinator of air conservation, and Daniel A. Hirschler, our director of automotive research.

We are very pleased to be here today for Ethyl is very proud of the contributions which it has made to the automotive industry through the development of the magic ingredient that has made "100 octane" synonymous with efficiency and economy throughout the world. The point was put succinctly by Mr. Cole, the president of General Motors, in a speech on January 14:

> In short, tetraethyllead permited the petroleum industry to increase the octane rating of its gasolines and improve their antiknock characteristics. This allowed the auto companies to boost compression ratios which resulted in improved engine efficiency and benefits—either in terms of economy or performance.

We don't think that contributions of this magnitude should be lightly regarded. The story we want to tell you today is not a new story. It is the same story of contributions which we have convinced industry of for many years—during all the years we were half owned by General Motors—and ever since.

This committee was one of the earliest crusaders against pollution; today, all Americans are crusading against pollution. We are, too, but we want the right solution, not temporary expedients that adversely affect the total ecology in the years ahead.

Unfortunately, since all of us want pure air, it is easy for the public to be stirred up by emotional appeals and impatient demands for shortcuts and easy answers. Many of us also like to find a scapegoat for unwelcome problems. It is far easier to shift the blame for problems than to solve them.

Today we are in the middle of a great emotional furor over lead antiknocks in gasoline. After living through the last 6 weeks—if you can call it living—there is no doubt in my mind that lead has been picked by some as the scapegoat for a host of serious problems of the automotive industry.

Therefore, the first part of my statement will be addressed to this recent furor that has created real confusion in the automotive, oil and related industries. This has taken on so many emotional and political overtones that it is difficult to discuss the matter in a rational manner, but we think the time has come to stop and take a long, hard look at just what is going on.

The second part of my statement will be addressed to the far-reaching provisions of section 5 of S.B. 3466 which we believe should be amended and revised to prevent an abandonment of the total systems approach to automotive emission control that we feel represents the best hope for a long-range solution to air pollution problems.

THE CURRENT FURORE OVER LEAD ANTIKNOCKS IN GASOLINE

The present furore was started early in January by Mr. Cole of General Motors who announced in his speech on January 14, 1970, that General Motors could not meet the 1975 emissions standards unless lead was removed from gasoline for that year's cars. But a couple of weeks later, Mr. Cole announced that lead-free gasoline would be needed this year because General Motors had determined to go back to the engines of some 15 or 20 years ago, and thus he attempted to shift to the oil industry the burden of meeting many of the tough pollution-control problems that have been imposed by law on the automotive industry.

The stated purpose of this change is that some members of the automotive industry claim they do not know how to handle some of the engine effects created by lead antiknocks which were invented by General Motors and which have been used in virtually all the millions of automobiles that have been produced over the last 40 years.

The Detroit position was changed again a few weeks later when Mr. Cole stated at a meeting of the California Air Resources Board on March 5:

> Now, in light of information we received yesterday, I believe General Motors could modify its position to some degree. We understand the problems that we didn't know about before a little better . . .

He then stated that General Motors could get along with about half a gram of lead antiknock compounds per gallon—about 20 percent of present levels—and still meet the standards through the 1974 model year.

We think we are all entitled to more advance "planning" out of Detroit than this. We think the much publicized sudden proposal to make cars with lower compression engines available in August and September of 1970 has seriously confused the total issue. Actually the publicity makes it clear that these cars can operate equally well on leaded or unleaded gasoline. So what is the purpose of all the publicity about needing a lead-free gasoline for the entire country within the next few months? We understand there will be no catalyst, no recycling device nor any other new emission control equipment added to these low compression cars. This is a cure that cures nothing.

You must take into account, if compression ratios are reduced for these 1971 model cars, the total amount of exhaust emissions will not in our opinion be reduced—rather, we think they will be increased. The carburetors of the low-compression-ratio cars have to be set for richer mixtures for the same degree of driveability. Fuel consumption and exhaust flow will be greater because of the lowered engine efficiency. The combination of these two effects will increase mass carbon monoxide emissions substantially. We believe nitrogen oxides may be reduced somewhat, but, in any event, the carbon monoxide formation will overshadow any slight decrease in hydrocarbons and nitrogen oxide emissions, and we think carbon monoxide is still probably the biggest problem, particularly in certain sections of the country.

We simply don't believe that any less efficient engine that burns more gas is going to help smog. Let me make it clear at this point, however, that we are not here today to argue for either a low-compression or a high-compression engine. We obviously have little or no voice in that decision. Either type can operate well on leaded gasoline and meet emission standards. But we do think you should recognize, which Mr. Hartke has just pointed out and Mr. Misch confirmed, that on January 27, 1970, Henry Ford II, said in a letter to a number of major oil companies:

> I would also appreciate knowing how soon you think lead might be removed from premium grade fuel so we might again build new cars with more efficient engines requiring higher octane fuel.

In view of statements like these, the decisions you make in the next few months must take into account the fact that any restriction on lead antiknocks will eventually require major reformulations of gasoline to meet not only the proposed 1971 model octane ratings, but also increased octane ratings in the years to come, when you and I and the rest of the public will want to drive again an efficient engine with all the present day power attachments—from air conditioning to automatic transmissions.

Those major reformulations of gasoline are what raise the question of the billions of dollars that will be required and also raise the new health questions that I will talk about in a moment.

Ethyl Corp., through its Detroit Research Laboratories, has been doing multimillion dollar research on the internal combustion engine and its emissions since the early 1950's.

Ethyl has been able to modify existing cars produced in Detroit to stay consistently below prescribed emission standards, using present-day leaded gasolines. We have such a modified car—a Pontiac, incidentally—or, that is, it looks like a Pontiac. It is an E-t-h-y-l—so there is no confusion with an Edsel, as somebody accused me of the other day—that already meets all U.S. and California standards through 1974 and partially meets the 1975 standards. We brought this modified car with us today, and it is located out in front of this building. I sincerely invite the members of this subcommittee to go down and see it and preferably drive it because I am completely satisfied that it is as good as any car on the road today. Mr. Cole of California called this an experimental prototype, but that is where all automobiles have to start from.

To give you an idea of the order of magnitude of these emission controls, let me show the results of this car compared with the present 1974 California requirements, the proposed 1975 HEW requirements and an estimate of what the levels were before the automobile industry started its dramatic work on reducing emissions.

(Chart follows:)

[In grams per mile]

	Estimated before controls	1974 California requirements	Proposed 1975 HEW requirements	Ethyl lean reactor car
Unburned hydrocarbons	12	1.5	0.5	0.55
Carbon monoxide	85	23.0	11.0	10.4
Nitrogen oxides	5	1.3	.9	1.3

I think it is perfectly clear when you say the unburned hydrocarbons, carbon monoxide, and nitrogen oxides are lower than before the control was started and—comparing this with out projected 1974 California requirements and proposed 1975 HEW requirements—it is perfectly obvious that this is dramatic progress.

It is my understanding that DuPont has developed mechanical emission control devices for cars that may do even better than our own. How many years can anyone expect scientists to stay ahead of the emission standards that have been set for the future? Even we are now 4 or 5 years ahead of schedule, and it had never occurred to us until January that the auto manufacturers could not continue to do at least as well, and I am delighted to hear Mr. Misch say that he thinks they can.

POSITION OF AUTO INDUSTRY

Now let's look for a moment at the position of the automobile industry today.

First, the mass of refining, distribution, and marketing problems for the oil industry stems from their suddenly saying they need lead-free gasoline by September 1970 for their new low-compression cars. But, as I have said, all of their publicity makes it clear that these cars can operate equally well on either leaded or unleaded gasoline. When and if lead-free gas is needed by Detroit, the oil industry has made it clear that it will produce it. But let's not use the lead issue as a political issue if it accomplishes nothing. Industry must spend millions of dollars in this world of pollution problems in the decade ahead. No industry can waste billions on any red herrings.

They claim that some day in the future they may be able to develop a practical catalyst to run only on unleaded gasoline. It is bound to be obvious that there is no need for you and me to drive inefficient cars at increased costs and for the oil industry to rebuild facilities during the years that they are experimenting in their laboratories on possible catalysts.

Ethyl and DuPont have independently done much work on catalysts for automobile exhaust for many years. We carried out and met qualification testing of a catalytic device in California in 1963–64 when that State's law required that such a device be developed for installation on automobiles operated on leaded gas.

This was in the days when it was claimed you couldn't get substantial reductions of emissions without a catalyst and yet you have seen what has been accomplished. The automobile industry concluded in 1964 that mechanical approaches to emission reduction were far more practical than catalysts.

Last week this committee heard claims that treatment of exhausts by a platinum catalytic device would reduce hydrocarbon and carbon monoxide emissions to low levels. This claim is not new. The very first catalytic systems tested in the 1950's used platinum.

However, we don't believe that even the automobile companies who claim they may some day have to resort to catalysts think that platinum is the answer. Just last May in an SAE paper reporting on an investigation of a platinum catalytic system, General Motors said:

> The catalyst used in this evaluation contained a noble metal. This is not practical for large volume uses because of the high costs and limited availability of noble metal. A catalyst is needed that does not use precious metals.

It is well known that the bulk of the known reserves of platinum in the world are controlled by Russia.

Incidentally, the same paper by General Motors reported that they had experienced exhaust valve problems with unleaded gasoline in the cars for their test programs. Valve seat wear was so extreme that the cylinder heads had to be replaced before the investigation could be completed. They stated in that report:

> It became evident that the exhaust valves and seats were sensitive to speed and load conditions operating on nonleaded fuel. The objective of this evaluation

was a catalyst study and not a study of exhaust valve seat wear, therefore, it was discontinued. However, it does point out that this problem exists and its significance must be recognized and evaluated.

So, as you gentlemen know, no one has a monopoly on problems these days.

Everyone is scouring the country today to try to find a practical catalyst, not platinum which is clearly fouled by today's gas. New potential catalysts are claimed almost every day, with many claims that they work with either leaded or unleaded gasolines. While we still doubt that the catalyst approach is the best way to proceed, we are naturally reexploring its possibilities, and we have recently received several exciting submissions in this field.

For example, we have recently obtained access under an inventor's secrecy agreement to a particularly interesting new catalyst that has been road tested for more than 30,000 miles in Europe in European cars and showed no substantial loss in activity when operated on leaded gas. Tests are now underway in American cars. Also, we are impressed by the recent announcement by Mobil Oil Co. of a new low emission car with a catalyst that works on both leaded and unleaded gasolines.

Certainly the catalyst approach is not the only answer. As I have said, Ethyl has developed a car without a catalyst that now meets 1974 standards on leaded gasoline.

In addition to emphasizing their catalyst problems, the Detroit people also say they will be unable to recycle exhaust gases to reduce the emission of oxides of nitrogen so long as leaded gasoline is used. Even Ethyl thinks it can effectively recycle exhausts right now on leaded gasoline, and such a recycling device is on the car right outside.

We believe there are many relatively simple devices to achieve effective recycling that present no more difficult problems with leaded gasoline than the many other parts of the automobile engine that have been operated on leaded gasoline for so many years.

HEALTH ASPECTS

There is no proof that lead in the atmosphere creates any health hazard to the public. This has been the subject of responsible, detailed investigation for many years. No health aspects have changed because of Detroit's new claim that lead complicates their own job. Ethyl and Du Pont, as well as various Federal agencies and the oil and lead industries, have probably spent more millions of dollars studying the health aspects of lead in air continuously over 40 years than has been spent by anyone studying any other substance in the entire atmosphere.

This matter was the subject of extensive inquiry by this very committee several years ago, and I think you all understand the complexities of the subject and how it can only be covered in depth by medical experts. This type of medical research has continued without interruption over many years.

We intend to continue our part of this research program as a normal precautionary matter since our first concern has been, and will continue to be, to safeguard the public health. We welcome such medical and health research by responsible parties since it is our conviction that the public interest can be served only by reliance on scientifically proved facts rather than on speculation and unproved "concerns" and theories.

In any event, even when any lead and particulate standards as proposed by HEW are effective, an obvious solution is to place a lead trap in a muffler on the exhaust system. Again, Ethyl and Du Pont have done a great deal of research and development work in preparation for meeting the 1975 particulate standards. Ethyl's data show that lead constitutes less than one-third of the total particulates in automobile exhausts. We now have working prototypes of particulate traps that will remove up to 65 percent of exhausted lead compounds, and we are testing more advanced trapping devices than can remove up to approximately 90 percent of all lead in the exhaust. Admittedly this involves one piece of hardware, but for billions of dollars, you can afford a little hardware. I am confident that we are at least as advanced in developing lead traps as Detroit is in developing effective catalysts.

All the public is ever told about are the alleged health questions related to lead in gasoline. Let's look for a moment at the side of the health story that gets little publicity.

It is clear that something has to take the place of the power that antiknock compounds have long provided, and this involves reformulations of gasoline. Lead adds octane—it is just that simple. If the refineries in this country can today get the gasoline up to, on the average, say 88 or 90 octane, the addition of antiknock compounds adds at least another seven or eight octane points. We all know that if you take the lead out of gasoline the refineries have to use some other method for increasing the octane rating and this normally increases the aromatic content of the gas. We know that everyone is very concerned about this feature of the total problem. In our opinion, the unknown health hazards of increasing aromaticity—the problems of carcinogens—outweigh the long-studied question of lead.

I don't see any reference to this point in the General Motors' prepared statement that I have just seen to follow me, but certainly Mr. Cole has expressed his concern about this feature both to me and in his recent testimony in California.

Certainly it is generally true that an increase in aromatics will increase the eye irritation of smog. General Motors recently testified on this subject in California on the basis of their smog chamber research. It is clear that when certain aromatics pass through the photochemical smog reactions they form a potent eye irritant which they admit is probably responsible for half the eye irritation in Los Angeles smog. The obtaining of octanes by lead antiknocks clearly minimizes aromatics.

SMOG EFFECTS

Let us look further at photochemical smog itself, which in the last analysis is what all of us ought to be most concerned about, and rightly so. The U.S. Bureau of Mines—not Ethyl Corp., mind you—has recently reported that:

> Leaded and comparable quality prototype unleaded fuels yielded about equal amounts of emissions. This was true for both evaporative and exhaust losses. If the photochemical effect is considered, the fuel factor is shown to exert significant influence. The fuel alterations from leaded to unleaded (gasoline)

changed emission characteristics so that the pollution effect was increased by as much as 25 percent.

Mr. Richard Hurn, the Director of Petroleum Research for the Bureau of Mines in Bartlesville, Okla., the author of this report, recently testified in California. He said he felt he had to qualify his report to emphasize that any switch to unleaded fuel could increase emissions by as much as 38 percent.

All of this testimony applies to the present 100 million cars on the road, whatever you think you may want to do in the future or may want to do about catalysts on new cars.

We think it would be a most serious mistake to risk any increase in smog in our country today. Independent investigations have clearly demonstrated that the presence of lead in gasoline does not increase the amount of photochemical smog produced by exhaust emissions, and eye irritation was not increased—indeed lead holds the aromatics to the minimum. Recent investigations demonstrate that the presence of lead actually decreases the amount of eye-irritating aldehydes in engine exhaust.

This is the side of the story that we believe the public has not been told. I frankly cannot understand why this is not clear to everyone.

ECONOMIC COSTS

Finally let's turn for a moment to the economic costs of the auto industry approach. First of all, assume that the proposed 91 octane unleaded gasoline is made available immediately for the new cars. It is abundantly clear that the costs of manufacture and distribution of the unleaded 91 octane fuel are significantly higher than for the presently available leaded regular fuels and that the new product must carry a higher price and result in more fuel consumption.

Certainly high octane gas will still be needed for the some 100 million cars on the road today until they are retired. This is the area that can create an urgent problem for the oil industry. If the refineries were required to provide the high octane gas for those cars without lead, then a crash program to restructure all of the country's oil refinery facilities would be required at a cost which we estimate will be in excess of $6 billion. This would create a tremendous inflationary demand for skilled labor and equipment at a time when there is barely enough of either to satisfy the normal growth of the oil industry. In addition to this unprecedented capital expenditure (probably more than the oil industry has spent on normal refinery growth in the last 10 years), there would be an increase in manufacturing and distribution costs requiring increases in gasoline prices of at least 2 cents to 4 cents per gallon. Even if these heavy financial demands can be met by the major oil companies, many (we think more than 100) independent refiners will be forced out of the gasoline making business if lead is eliminated.

In summary, we think you gentlemen and the public should be clearly advised that any premature decision to remove lead from gasoline will be likely to increase—not decrease—photochemical smog and exhaust emissions, and further will impose a tremendous and unnecessary inflationary cost on the entire economy.

PROPOSED ALTERNATIVE TO SECTION 5 OF S. 3466

The proposed amendments contained in section 5 of S. 3466 are a reversal of your carefully worked out regulatory scheme embodied in the Air Quality Act of 1967. That legislation empowered the Secretary to set standards for emissions from the exhaust pipe of the automobile and left it up to private industry as to how to meet such standards. The legislative history makes it clear that the intent was to promote technical innovation and competition and thus to leave "all the options open" for the automotive and oil industries.

Now you have before you a proposal for the Secretary of HEW to regulate in minute detail the composition and chemical properties of fuels and fuel additives used in automobiles. This is a new and drastic approach. At the same time, there is nothing in S. 3466 which would grant the Secretary comparable regulatory power with respect to the automobile manufacturers. There is no way for the Government to require them to continue with any low-compression car or to require them to place any particular control devices on any car, regardless of whether that may be the best and cheapest total approach to the exhaust emission problem.

It still seems clear to us that the approach adopted in 1967 of controlling what comes out of the exhaust pipe is the soundest approach. We think going back into each of the various components of the total problem is going to involve Government in a messy morass of problems.

Certainly we think S. 3466 is making a giant step backward by seeking to isolate and regulate only one of these elements while leaving such other elements as the automobile engine free of any direct regulation, supervision, or disclosure requirements.

If, however, you conclude that any additional authority is needed, it is our view that the bill should be amended in the following manner:

First, subsection (b) should be deleted. If anything is clear from the past few weeks of news in this field, it is that the oil companies are willing to make available such fuels as Detroit needs—even though they may well hope for more forward planning than was involved in this recent request.

If in fact Detroit needs and makes new engines with new fuel requirements, of course we can't object, any more than we could object when the high octane piston airplanes converted to jets. No law was required for the jets to get the fuel they needed.

More importantly, by eliminating this section, the wisdom of the 1967 act approach will be left intact, leaving "all the options open" to the solution of the emissions problems.

Second, we have no objection to that portion of subsection (c) carrying forward the language of the 1967 act requiring specific information on fuel additives prior to their registration. I might observe however in this connection that the Secretary has not yet utilized the power to gather even that information about the fuel additives that Congress gave him in 1967.

Third, we have no objection to authority being given the Secretary to gather information, in addition to and apart from his present authority relating to additive registration, to permit the evaluation of the effectiveness of the various proposed emission control devices or systems and developing a comprehensive cost-benefit analysis of these alternative approaches to emission control. This system analysis should be comprehensive, requiring not only information from the oil and additive industries, but from the automotive manufacturers as well.

Fourth, the Secretary of HEW should be empowered to call conferences and promote joint research-and-development work by the automotive or related industries to facilitate the prompt attainment of emission standards in the most expeditious, economic and technically feasible manner. Presently, the Secretary apparently feels this cannot be done under the antitrust laws. His apprehensions should be relieved.

If the Secretary will exercise these powers to get information from all involved in this total complex process, including the evaluation of the economics of competing approaches, we think he will then be in a position to request precise authority, if any is needed to augment his present powers for controlling what comes out of the tailpipe.

In the meantime, we think your approach of setting emission standards is meeting with dramatically swift success. As the standards become increasingly stringent, as they were designed to become over the years, we urge you not to let the automobile companies claim 2 weeks after the start of the environmental decade that they cannot meet these long-established goals, and try to put the blame elsewhere. We have no doubts that your goals are achievable under a variety of routes.

We appreciate very much the opportunity to appear before you today, and we will be pleased to try to answer any questions you may have.

Senator EAGLETON. I knew you would have a very important point that you want to make for your company, and you should make it as complete as you can.

Mr. BLANCHARD. I do have 15,000 employees and 15,000 stockholders and I would like to give them each a minute.

Senator EAGLETON. We understand. I will just ask you one question and then I will yield.

Do you object to legislation giving the Secretary of HEW authority to set standards for fuel composition and fuel additives; standards which would be based on health and welfare effects of such fuel.

Mr. BLANCHARD. We do at this time for the reasons I have said, that we think the approach is to regulate what comes out of the tailpipe and stick to that approach. If you ever conclude that that is not getting you to the standards you need and you have got to go up the system, then if you go up the system, don't stop at any part of that system because anyone knows that fuel composition and what happens to the fuels in an engine and the way that the engine is designed and what the compression ratio is, that those two questions are so completely intertwined that we simply don't think you can isolate them.

Senator EAGLETON. Senator Hartke.

Senator HARTKE. With regard to this prototype, is that what you called the lean reactor car?

Mr. BLANCHARD. Yes, sir.

Senator HARTKE. What is the estimated life of this reactor?

Mr. BLANCHARD. This is one I would like to indulge in the luxury of calling on my expert in charge of the lean reactor car, Mr. Dan Hirschler.

Mr. HIRSCHLER. Well, our estimate is that this is a system that should have the potential for lasting the life of the car. It is a hardware system, there is nothing——

Senator HARTKE. I did not hear that word.

Mr. HIRSCHLER. I just said it was a hardware system. There is nothing that is really greatly different from the type of hardware on cars right now. I would like to draw a little distinction between the type of system we are working with and perhaps others that might appear similar. Our system is based on the premise of operating the engine very lean and burning as much in the combustion chamber as possible and leaving as little to come out later to be treated as possible. Therefore, even though we do have what we call a gas reactor on the engine, it is one that operates at a relatively low temperature and has very little to burn.

Senator HARTKE. Does this reactor suffer deterioration in the driving of the vehicle?

Mr. HIRSCHLER. In our work with these cars we have driven them in normal service. For example, we drove the one that is sitting in front of the building from Detroit the other day and we have driven it around to other parts of the country. This particular car has about 20,000 miles on it with the system and it has shown no evidence of deterioration. We have other cars that represent predecessors, slightly earlier versions of this car, that we have had even more driving experience on which no indication that there really is a problem here.

Senator HARTKE. Do you use the same type of testing on this vehicle that is being used by other Federal testing procedures or are you just talking about the procedure of driving to Washington from Detroit?

Mr. BLANCHARD. In terms of measuring emissions, of course, we use standardized procedures.

Senator HARTKE. I am talking about deterioration now on the overall way in which the vehicle itself works; in other words, what happens to it?

Mr. HIRSCHLER. This has been done in consumer-type service. For example, one of the earlier versions of the car we did send around to be used by the different regional offices of our company a year or so ago and in this service the car was subjected to a lot of different drivers that went from coast to coast, mountains and deserts, and so on, for about 25,000 miles and when it got back to Detroit its emissions were lower than when it left.

Senator HARTKE. Let me ask this question of you. You know, on the prototype, there has to be a 50,000-mile test for durability, is that correct?

Mr. HIRSCHLER. Yes.

Senator HARTKE. Have you submitted this vehicle to that type of testing?

Mr. HIRSCHLER. We have not as yet. This car is like Mr. Blanchard said, 4 or 5 years ahead of its time, and we have not had a chance to do everything we want to on it. Up to now, much of our work has been developing the content, making it practical, and getting into these things. As I mentioned, and you could probably not hear, one of the earlier prototypes of this car, our predecessors of the current one, that is out in front of the building, a year or so ago we made it available to the different regional offices of our company. It was driven all over the country, in the mountains and the deserts and coast to coast for about 25,000 miles, and finally it was returned to Detroit with lower emissions than when it left.

Senator HARTKE. With lower emissions?

Mr. HIRSCHLER. Than when it left; yes.

Senator HARTKE. Do you have the results? I think you are dealing here with durability and we will come back to the question ultimately of cost.

Mr. HIRSCHLER. Yes.

Senator HARTKE. You say you have not submitted it to the durability test as other prototypes. Is that correct?

Mr. HIRSCHLER. Not as yet.

Senator HARTKE. Any of the prototypes?

Mr. HIRSCHLER. Not to the formal type of 50,000-mile test.

Senator HARTKE. Can you give us the result of the durability, of the deterioration which involves the reactor? Can you provide that for the committee?

Mr. HIRSCHLER. I can give you the emission results of this car.

Senator HARTKE. I am talking about durability first.

I mean not today, if you can provide it for the record.

Mr. HIRSCHLER. Yes. We will put it together.

Senator HARTKE. You would be willing to submit that for the committee?

Mr. HIRSCHLER. Yes.

Senator HARTKE. Now, with regard to the emissions, either today or otherwise, could you give us the results of the emission, say, 4,000 miles and 10,000 miles, 20,000 miles or 25,000 miles and 50,000 miles?

Mr. HIRSCHLER. Sometime in the future we can do this.

Senator HARTKE. What are you talking about "future"? How many years, months, days?

Mr. BLANCHARD. Senator, may I ask one question?

Senator HARTKE. Yes.

Mr. BLANCHARD. Let me explain one thing about this system that we call the system on our lean reactor car. This is merely an approach that we have been pursuing now for 3 or 4 years and when I say this is a Pontiac it happens to be a 1967 Pontiac. That is of no significance in terms of anything other than this is the type of car we started building these things in and we keep going through new generations of improvements constantly to upgrade the various refinements that we think can be put on them. So each time we put another refinement we run them, we think, a reasonable period of time to test the emission standard—just exactly how the car runs with the prototype. That is what all of these figures are on page 5. We have not, generally speaking, stopped each time and said let's don't continue with further improvement to show what the possibilities are for this car and stop everything until we can run those tests, but we do have certain data on durability that I am sure we can provide within a matter of a few days.

Senator HARTKE. I mean if you point this out as an alternative to the continuation of utilization of a lead gasoline, and that is what I understand you to point it to——

Mr. BLANCHARD. Right.

Senator HARTKE. Certainly the question, then is: What is the durability of such a reactor and what is the deterioration? Is it submitted to the same test as the other prototype as to durability on the question of emission? Isn't that fair?

Mr. BLANCHARD. Yes; it certainly is fair.

Senator HARTKE. Don't you think rather than leave it dangle that maybe you ought to look at it a little more in detail?

Mr. BLANCHARD. Yes; I agree completely. I certainly do not want to leave you gentlemen with the impression that we contend in any way, shape, or form that this prototype we have out there, that we can make that car or any other car better than or remotely as well as the Detroit automobile manufacturers can make them. This car has been built to demonstrate certain system techniques that we think are feasible and practical approaches. We think that there are many, many refinements and improvements that can be built into this concept, and it is merely to illustrate a concept that can be taken.

We do not suggest that this car is any final answer, by any means.

Senator HARTKE. As much as I am concerned about leaving the impression that removing lead is going to solve the problem, I am just as concerned about the fact that you leave the impression that if you continue to use lead and use this prototype that you have the answer. What I am trying to avoid is this business of self-deception and in the meantime nothing happens. I think in that, of course, comes that elephant problem, what does it involve as far as procurement cost? How much would it add to it? Do you have any idea at all?

Mr. HIRSCHLER. Well, this is another difficult one. As we mentioned, it is pretty much an integrated system. It is not a case of adding a specific device that you could cost out. What it amounts to is redesigning some of the portions of the vehicle that are normally there, things like the carburator and exhaust systems and so on. So the fact that we are talking about making changes rather than a specific device, it becomes very hard for us to come up with an exact figure.

Senator HARTKE. Do you have an estimate?

Mr. HIRSCHLER. If you make an estimate on a very qualified basis of that sort, we would think in terms of $100.

Senator HARTKE. $100 a unit on procurement?

Mr. HIRSCHLER. This would be a neighborhood figure.

Senator HARTKE. What about the maintenance of it? What about replacement?

Mr. HIRSCHLER. This is an approach that involves hardware and that should be good for the life of the car.

Senator HARTKE. You have no real estimate as to durability, though?

Mr. HIRSCHLER. Well, this is correct. We have been making continual changes and improvements pretty much as we go along and have not placed it in one specific configuration to run an extensive series of durability tests.

Senator HARTKE. As far as fuel, would it use the same fuel you have today in the marketplace?

Mr. HIRSCHLER. Yes.

Senator HARTKE. Is that what you are contemplating?

Mr. HIRSCHLER. Yes.

Senator Hartke. Now, Mr. Blanchard——

Mr. Blanchard. Senator, could I say most sincerely that we would invite you to look at the display that we have in front of the building? It shows the component parts that you are talking about putting on the engine which are not some new devices, and I think you would appreciate much more fully what Mr. Hirschler is saying. I am sure you have plenty of spare time.

Senator Hartke. At this moment I have two notices that the Sergeant-at-Arms wants us on the floor of the Senate before I go out to look at that car.

You make the statement that Mr. Cole, who is to testify later, attempted to shift to the oil industry the burden of meeting many of the tough pollution control problems that have been imposed by law in the automobile industry. I guess I have been responsible for a lot of those in the automobile safety bill in the Commerce Committee.

Let me ask you, Is there any reason why the oil industry should not be subjected to the same type of control as the automobile industry in the interest of safety? I mean, do they have any special claim on bein exempted?

Mr. Blanchard. No, indeed. I don't mean to imply that. What I think we are talking about is exactly what I think you were getting at a moment ago in your questions and that is that their position has raised in one fell swoop the basic economic questions that I think we ought to be facing up to: that is, whether or not it is cheaper to put a given device on a car or is it cheaper to spend $6, $18, or $25 billion to reformulate the gasoline and just take the flat position, you do something about that instead of our putting the devices on.

Now, maybe that will end up being the appropriate approach, but at the moment it seems to me without their realizing the potential economics they have shifted the burden to them.

Now, whatever fair burden should be shifted, if it turns out that there is no way to do it except the route that they are suggesting, then I won't say that they ought to bear their fair share, you understand. I don't speak for the oil industry or their customers.

Senator Hartke. The amount of lead that goes into gasoline now is controlled, is it not?

Mr. Blanchard. Yes, that is correct.

Senator Hartke. What the automobile industry is not saying is that they are going to have a lead-free gasoline, but that they are going to reduce the amount, isn't that true?

Mr. Blanchard. That is what has been the constant shift. Up until 2 weeks ago, they said we had to have lead free or there was no catalyst that would work on any lead.

Senator Hartke. All right.

Isn't the reduction of lead at least a step in the right direction then?

Mr. Blanchard. For the reasons I have put in here, we do not believe that is the right course because we think that the economics, and, in our opinion, health benefits, of having it in are better than taking it out and, therefore, we certainly do not agree that it is a step in the right direction.

Senator Hartke. You are familiar with the testimony here submitted before by one Vincent Shaffer of the University of Albany.

Mr. Blanchard. Yes.

Senator Hartke. Are you familiar with his conclusions there that a nuclei which is being formed from some source is, in their opinion, due to the fact that the lead which is found in the atmosphere itself has only occurred in those areas heretofore where they had purposely introduced lead found in certain high-density areas where the pollution from the automobiles occurs and that in his opinion such areas are so extensive he could exert an effect on the weather patterns over America? Does that concern you?

Mr. Blanchard. We have heard so many accusations of this type since 1920, including that lead was responsible for the fall of the Roman Empire because of the lead acqueducts, that this sort of thing we simply are not prepared to accept without knowing a great deal more about it.

Second, I have never been able to understand from his point what effects he is talking about on weather. I have never been sure whether that is good or bad. I suppose it depends on whether you want rain or don't want rain at a given time or in a given area.

I simply can't get from his testimony whether the fact it has some effect on rain is necessarily good or bad.

Senator Hartke. If it seriously affects the weather patterns, it adversely affects, that is what I assumed he meant.

Mr. Blanchard. What he talks about, though, is that certain concentrations in certain areas affect rain and I suppose that depends on whether you want a picnic or want to grow crops. I don't know what he means by weather that is adverse or not.

I am being very serious. I am not trying to be flip about it, I mean it. I honestly do not know what he means by saying that it could have an effect on the amount of rain.

Senator Hartke. This, I think, is the heart of the problem. You are looking to an alternative to the utilization of fuel with lead. You are looking to an alternative to the internal combustion with the utilization of some lead content in gasoline. That is what your alternative is.

Mr. Blanchard. Not an alternative to the internal combustion engine.

Senator Hartke. You are looking to the utilization of the internal combustion engine in the system to eliminate lead.

Mr. Blanchard. That is correct.

Senator Hartke. That is the basis of your testimony here today.

Mr. Blanchard. Yes.

Senator Hartke. Isn't there the other alternative which you ignored in your testimony and that is the alternative to the present internal combustion engine, either the utilization of some gas turbine or a steam engine which is called the Rankin engine? Isn't that an alternative which also merits consideration?

Mr. Blanchard. We have no position of any kind on that subject any more than we had at the time the piston airplane went to jets—which, incidentally, uses absolutely no lead, it uses a fuel that does not have anything to do with lead. Any time you design a new system that uses a different fuel to run, for example, a jet engine, obviously the other corporation has no objection of any kind. We may be sorry but we can have no objection because obviously we don't sell lead to anybody except customers who need it to perform a purpose.

Now, if anyone can come up with a steam engine or a turbine, under no circumstances do I want to be put in the position of saying that we are against doing tremendous research and attempting to arrive at that goal.

I am not a bit opposed to that.

Senator HARTKE. I think I understand.

The estimates I have from some of the so-called experts for a complete retooling job for an alternate engine to the internal combustion would cost in the neighborhood of about $1,200 million and maybe the car would cost about $100 more compared to the estimates I have of about $18 million to try to make the adjustment to the present internal combustion engine. If those estimates are anywhere near being realistic, I think it is only fair that we not only consider alternate utilization of the internal combustion engines, but alternates to the engine itself as long as we can maintain durability.

Mr. BLANCHARD. Absolutely. Not only do we not have any objection to that, we support completely all the research that can be done on any automotive device of any kind.

Senator SPONG. Senator Dole?

Senator DOLE. Just briefly, because we do have a call by the Sergeant-at-Arms.

Now, I would assume your testimony, Mr. Blanchard, also would relate to the amendment offered by Senator Montoya to S. 3229. You didn't comment on that specifically, but the amendment states:

> The Secretary shall, as soon as practicable, prescribe such standards with respect to the composition of fuels of all types that are necessary to protect the public health and welfare and carry out the policy of this Act.

Do you have any comment on that specific amendment, or just on S. 3446?

Mr. BLANCHARD. I suppose the thing that every lawyer has to confess at some date is that he is caught unprepared. In the sense that I had understood that S. 3466 was the bill that related to the precise subject we are concerned with, I would like to say I am opposed to that one, too, but I don't want to be in that position because, frankly, I have to confess I have not read that bill. I am sorry.

Senator SPONG. Why don't you review that and submit for the record any comments?

Senator DOLE. The only reason I asked the question was to make certain that you covered all the pending proposals, to avoid additional testimony at a later time. That is a printed amendment and it will be made available to you for comment.

Mr. BLANCHARD. I am sure it is my fault for not being up on that one, and I apologize.

(Subsequently, Mr. Blanchard filed the following information:)

ETHYL CORP.,
Richmond, Va., April 13, 1970.

Hon. EDMUND MUSKIE,
Chairman, Committee on Water and Air Pollution of the Committee on Public Works, U.S. Senate, Washington, D.C.

DEAR SENATOR MUSKIE: During the course of my testimony before the Subcommittee on March 25, Senator Dole requested that the Ethyl Corporation file its comments on Amendment 501 introduced by Senator Montoya to amend S. 3229. We appreciate the opportunity at this time to express our views on this proposed amendment to the Clean Air Act of 1967.

This Amendment would authorize the Secretary of HEW to establish such standards with respect to fuel composition as are necessary to protect the public health and welfare.

Initially, most of my testimony on S. 3466 applies equally to our views on Amendment 501. As I stated before the Subcommittee, we strongly believe that Section 5 of S. 3466, as well as Amendment 501, reflect an unfortunate departure from the carefully worked out regulatory system embodied in the Clean Air Act of 1967. In that Act Congress empowered the Secretary of HEW to establish progressively stringent *emission* standards for the automobile. Congress thereby correctly sought to limit the pollutants emitted from the exhaust pipe into the atmosphere. S. 3466 and Amendment 501 now seek to regulate but one limited element—fuel composition—of the many components of the automobile which affect emissions into the atmosphere. By contrast, neither of these bills seek comparable authority to regulate those aspects of the automobile, such as the engine, the combustion process or the exhaust system, which effect emissions as much or more than the fuel used.

Consequently, as a general comment, we would say that Amendment 501, like S. 3466, is both an inadequate and unsound approach to controlling automobile emissions.

Specifically, Senator Dole's request for our comments on Amendment 501 to S. 3229 were in relationship to the effect, if any, of lead in the atmosphere on the public health. As we stated before the Subcommittee, there is no proof that lead in the atmosphere creates any health hazard to the public. There has been a vast amount of research carried out as to the public health effects related to the discharge of lead antiknock compounds. Research conducted by government, universities and industry investigators has been under way since the commercial introduction of lead antiknocks in 1923 and is continuing. This research has been referred to as one of the most extensive investigations of this nature on any single class of generally used chemical compounds. Understandably, there have always existed two schools of thought on the subject and this will probably always be the case. As a result, there have been numerous reviews of the situation and many investigations and conferences.

In the mid-1920's, after considerable scare propaganda relating to the possible effects of widespread dissemination of lead in vehicle exhaust, the entire situation was investigated with the best available technology. At that time, the Public Health Service concluded that there was no reason to prohibit the use of lead antiknocks. Government and industry studies since that time have repeatedly substantiated these initial medical findings.

In 1959, an ad hoc expert medical advisory committee of the Surgeon General of the U.S. Public Health Service again reviewed available information pertaining to all aspects of the use of lead antiknocks. This committee concluded that raising the maximum allowable concentrations of lead antiknocks in motor gasolines from 3 to 4 milliliters per gallon would not significantly increase the hazard to public health from air pollution (Reference 1). The average usage of lead in motor gasoline in the United States has always been substantially under the agreed upon maximum values and at present time the usage is on the average about 2.5 milliliters per gallon.

The Surgeon General's committee did feel there was a need for additional information relating to the contribution of lead antiknocks to the atmosphere and the body burden of the population. As a result, an extensive industry-government investigation was initiated in 1961. This one-year study assessed the concentration of lead-in-air of three major cities—Philadelphia, Cincinnati and Los Angeles—and also lead body burden as indicated by the lead content of the blood and urine of some 2400 men and women residing in these areas. These studies showed that atmospheric lead levels were on the average generally low and that lead body burden of the population including traffic policemen, downtown postmen, taxicab drivers, etc. were within the levels generally considered normal. These findings, as published by the U.S. Public Health Service, are summarized in Reference 2.

To assess possible changes which may have occurred during the intervening period, an extended survey of similar nature is now under way, again supported jointly by the U.S. Public Health Service and industry. The original three cities are being re-assayed, both aerometrically and biologically, and in addition, four major cities—Washington, D.C., New York, Chicago and Houston—have been added to the study. The results of this comprehensive program are anticipated upon completion of the sampling and analytical work in mid-1971.

The World Health Organization in 1967 reviewed the general lead situation as indicated by blood and urine analyses of individuals in some 16 different nations. A report of their studies is covered by Reference 3. Two statements from this document are felt to be significant:

"There has been no increase in lead contamination in the last two decades. If there has been any change it would appear at present man is exposed on the whole to less lead in his environment than he was twenty years ago."

"The lead levels reported in the blood of New Guinea aborigines are of particular interest in that they demonstrate that these natives living in the hills of New Guinea away from industrialization and motorization showed blood lead levels higher in range than urban and rural Californians."

The report did caution against complacency and indicated that the situation should continue to be evaluated and this is being done.

In response to the allegations relating to the hazards of the continued usage of lead antiknocks by Professor Clair C. Patterson, a geochemist from California Institute of Technology and referred to by Senator Dole, the American Medical Association commented in the February 1966 issue of Archives of Environmental Health as follows:

"The Committee on Occupational Toxicology of the Council on Occupational Health of the American Medical Association has reviewed with interest the article by Clair C. Patterson, PhD, in the September 1965 issue of the Archives. Whereas it feels it has no basis on which to judge Dr. Patterson's ability as a geochemist, it does at the same time feel obligated to point out that *some of Dr. Patterson's conclusions in the biological field are open to serious question as to their validity. The Committee feels obligated to point out that as a result of years of careful clinical study in workers in the lead industry significant, subtle, and unrecognized or 'unrecognizable' changes are not occurring in the general population as a result of its exposure to environmental lead. In fact, this vast clinical evidence, evaluated by a great number of clically trained scientists, suggests that the general public is not now, nor in the immediate future, facing a lead hazard.*" (emphasis added)

Further commenting on the Patterson allegation, Professor Thomas J. Haley of the University of California, School of Medicine, Los Angeles, made the following comment, "The supposed chronic lead intoxication from the environmental contamination is a myth not a fact." See Reference 4.

Largely as the result of the Patterson allegations, the Public Health Service held a "Symposium on Environmental Lead Contamination" in December 1965. A successful effort was made to bring together persons representing the widest possible range of informed scientific opinion on the subject of lead. The proceedings are reported in Public Health Service Publication No. 1440, March 1966. The major conclusion reached was that there was need for additional research as a precautionary matter.

The petroleum and lead-producing industries have sponsored a number of reviews of the available information relating to the possible health effects relating to lead antiknocks. These are contained in References 5, 6, 7 and 8.

To summarize our position, we do not believe that there is at present or in the foreseeable future a public health problem related to the use of lead antiknock compounds. For this reason, we do not believe that there is any necessity to empower the Secretary of HEW, as Amendment 501 to S. 3229 would do, to regulate the amount of lead antiknocks included in the fuels utilized today in operating automobiles.

If, however, the Secretary does feel, either now or at some future date, that lead emissions do pose a health problem, he already has the authority under the Clean Air Act of 1967 to restrict them to levels he would believe compatible with the public interest by setting emission standards. Industry can respond to any such restrictions on lead emissions by the installation on the exhaust system of a modified muffler containing a particulate trap. In this respect, Ethyl has already done a great deal of research and development work in preparation for meeting the 1975 particulates in automobile exhaust. We now have working particulate traps that are removing up to 65% of exhausted lead compounds and are testing more advanced trapping devices that can remove up to approximately 90% of all lead in the exhaust.

It should also be noted that the concerns expressed by Dr. Vincent Schaefer to the Subcommittee, and commented upon by Senator Hartke in his questioning of me, on the alleged, but imprecise, meteorological effects of lead in the atmosphere could easily be met by the installation on present day automobiles of a modified muffler containing a particulate trap.

In summary, it is our view that Amendment 501 is both unwarranted and unsound. We firmly believe that the evidence to date with respect to public health indicates no necessity to regulate the amount of lead antiknocks included within the composition of present day automotive fuels. If, however, it is felt now or at some future date that lead emissions should be controlled in the interest of public health, both the authority to impose such restrictions in the form of emission standards and the technology to meet such restrictions is presently available.

We appreciate this opportunity to commend upon Amendment 501 to S. 3229 and would be more than please to respond to any additional questions you or other members of the Subcommittee may have on this bill or any other proposed amendment to the Clean Air Act now pending before the Subcommittee.

Sincerely yours,

LAWRENCE E. BLANCHARD.

REFERENCES

1. Committee's Letter of Recommendation, March 30, 1959, from "Public Health Aspects of Increasing Tetraethyl Lead Content in Motor Fuels," a report by Advisory Committee on Tetraethyl Lead to Surgeon General of Public Health Service, U.S. Department of Health, Education, and Welfare.
2. "Survey of Lead in the Atmosphere of Three Urban Communities: A Summary," J. H. Ludwig, D. R. Diggs, H. E. Hesselberg and J. A. Maga. American Industrial Hygiene Association Journal, Vol. 26, May-June 1965.
3. "An International Study of 'Normal' Levels of Lead in Blood and Urine," by Leonard J. Goldwater, MD, and A. Walter Hoover, MD, Arch Environ Health, Vol. 15, July 1967.
4. "Chronic Lead Intoxication from Environmental Contamination: Myth or Fact?", by Thomas J. Haley, PhD, Arch Environ Health, Vol. 12, p. 781, June 1966.
5. "Air Qaulity Standards for Lead," Air Quality Monograms, Monograph No. 69–11, American Petroleum Institute.
6. "A Review of the Toxicology of Lead," Air Quality Monograms, Monograph No. 69–7, American Petroleum Institute.
7. "Lead in the Environment—A Background Paper," Committee on Public Affairs, American Petroleum Institute.
8. "Facts About Lead and the Atmosphere," Lead Industries Association, Inc.

Senator DOLE. Then, finally, I note you contend that there has been no evidence that lead in the atmosphere creates any hazard to the public. I am not certain of all those who may disagree, but apparently there are some. I would refer to testimony before this committee on June 15, 1966, when Dr. Patterson of the California Institute of Technology was a witness. He made a rather positive statement that there was a direct link between lead in the atmosphere and health. So, it appears there is a difference of opinion which I can certainly appreciate. You don't have to accept the opinion, but you did make a flat statement there is no proof.

Mr. BLANCHARD. That was carefully chosen as proof. We have heard the statement from Dr. Patterson for many years. He testified here before this committee, when the whole health aspects of the matter were gone into back in 1963, against quite a barrage of other medical testimony from all over the area. Following that, the conclusion of this committee was that the matter should be investigated in great depth by the medical experts, and this type of research has been going on ever since and, we still think it is fair to say, without there being any proof. I do not say that there have not been accusations.

Senator DOLE. Let me submit for the record an announcement today by Secretary Stans that he has appointed a panel to study tetraethyl lead and auto fuel as an air pollutant. You may not be aware of this.

Mr. BLANCHARD. We have been awaiting this announcement of the appointment of the actual members of the committee, but I have not seen this morning's Post.

Senator DOLE. The appointment of this panel indicates a concern for the problem. It should give you, as well as others, an opportunity to present your views. I am not familiar with those on the panel; you may be.

Mr. BLANCHARD. As I say, I have not even seen it. I don't know who is on it. Again, this is really our whole point: that this type of inquiry is what needs to go on, to look at the total economic impact of this total problem and its interrelationship between the automobile company and the oil company, and additives, before you can get a feel for whether someone should have the right to just regulate fuel composition and until you know what is involved in the economics of it.

Senator DOLE. If there is no objection——

Senator SPONG. It will be admitted for the record.

(The announcement referred to follows:)

[From the U.S. Department of Commerce News, Washington, D.C., Mar. 25, 1970]

SECRETARY STANS APPOINTS PANEL TO STUDY TETRAETHYL LEAD IN AUTO FUEL AS AIR POLLUTANT

Secretary of Commerce Maurice H. Stans has appointed a Panel on Automotive Fuels and Air Pollution to study all the implications of removing tetraethyl lead from automotive fuels—believed to be a prime pollutant of air in our cities. Three Departments—Health, Education, and Welfare; Transportation; and Commerce—are jointly supporting the study.

The Secretary named Dr. David V. Ragone, Professor of Engineering at Carnegie-Mellon University in Pittsburgh, to chair an eight-man panel of experts from industry and universities.

"This important step is part of President Nixon's determination to clean up our air supply," Secretary Stans said. "The work of the panel should help to meet the President's goals in air pollution control."

The Secretary said he has asked the panel to make a preliminary report to him within 90 days through the Department's Technical Advisory Board, which is chaired by Myron Tribus, Assistant Secretary for Science and Technology. It will also be available to the Council on Environmental Quality headed by Russell E. Train.

Recognizing the complexity of the study, the Secretary said that all the implications of tetraethyl lead removal would be carefully examined: engine performance, resource allocations, and the economics of making modifications in fuel and engine design. The objective, he said, is to achieve as a minimum the projected automotive emission goals of the Department of Health, Education, and Welfare.

The preliminary report will be followed by a final report which will deal with the larger question of additives in general.

"The panel will be expected to recommend specific policies with regard to required changes in engines or fuels or both to achieve appropriate reductions in emissions," the Secretary said. "It also will recommend specific standards and procedure for controlling the additives to gasoline; plans for instituting necessary programs for modifying either engines or fuels; and strategies for marketing new fuels and engines without making obsolete existing vehicles and fuel supply equipment."

The Commerce Technical Advisory Board was chosen to make this study because of its previous pioneering report on "The Automobile and Air Pollution," published in the fall of 1967, Secretary Stans said.

Members of the panel, in addition to Dr. Ragone, are: Dr. John D. Baldeschwieler, Professor of Chemistry, Stanford University; James L. Dooley, Vice President, Adavnced Development Division, McCulloch Corporation, Los Angeles; Owen P. Hall, Jr., Systems Analyst, TRW, Inc., Redondo Beach, California; Dr. Frederick J. Hooven, Adjunct Professor of Engineering, Thayer School, Dartmouth College, Hanover, New Hampshire; Professor Donald L. Katz, Department of Chemical and Metallurgical Engineering, University of Michigan, Ann Arbor; Dr. Eric R. Morgan, Executive Vice President, Stainless & Strip Division, Jones & Laughlin Steel Corporation, Warren, Michigan; and Professor Ernest S. Starkman, Professor of Mechanical Engineering—Thermal Systems, University of California, Berkeley. Robert M. Winfree of the Department of Commerce is Executive Secretary.

Senator SPONG. Mr. Blanchard, we thank you for your testimony. Your testimony raises some question about the removal of lead from gasoline, questions that will have to be answered during the consideration of this legislation, both with regard to health effects and economic cost.

I would like to say for the benefit of those here that we will resume at 1 o'clock. The next witness will be from the General Motors Corp., and we will start as shortly after 1 o'clock as we can return. Thank you.

Mr. BLANCHARD. Thank you, Mr. Chairman.

(Whereupon, at 12:28 p.m., the joint meeting recessed, to reconvene at 1:00 p.m., the same day.)

AFTERNOON SESSION

Senator SPONG. Is Mr. Chenea here?

STATEMENT OF PAUL F. CHENEA, VICE PRESIDENT, GM RESEARCH LABORATORIES; ACCOMPANIED BY FRED W. BOWDITCH, DIRECTOR, EMISSION CONTROL, GENERAL MOTORS ENGINEERING STAFF; AND JOHN D. CAPLAN, EXECUTIVE DIRECTOR, GENERAL MOTORS RESEARCH LABORATORIES

Mr. CHENEA. Chairman Spong, I am vice president of General Motors and in charge of the corporation's research laboratories. In the interest of shortening this proceeding, as you stated earlier, I believe I can make my statement in about 5 minutes.

Senator SPONG. That would be fine, Doctor. We will receive your statement for the record in its entirety, and you may testify from it as you choose.

Mr. CHENEA. I will pick and choose the important points, and it will only take about 5 minutes.

Senator SPONG. Thank you.

Mr. CHENEA. With me is John D. Caplan, executive director, GM Research Laboratories.

I have been associated with General Motors Research Laboratories since June 1967. Prior to that, I was with Purdue University and the University of Michigan, and served as a consultant to government, as well as industry.

We welcome this opportunity to appear today to present our views on behalf of General Motors, and offer information concerning the legislation before you.

I would like to point out at this time that Dr. Bowditch, director of emission control, has joined me.

We have endorsed, and continue to endorse, the extension of the

Clean Air Act. In addressing ourselves to the bills extending the act, we would prefer to discuss subject areas raised by the legislation rather than commenting on the specific provisions of each bill.

We offer the following observations in regard to the legislation: (1) Under standards set to date as a result of the Clean Air Act, remarkable reductions have been achieved in vehicle emissions, and there will be continuing reductions; (2) the Clean Air Act has been reasonably and fairly administered; (3) we are in no position to judge the adequacy of the level of the financing provisions of the legislation and feel that the subcommittees are in better position to determine this.

As to certain other aspects of the legislation before you, we offer these comments: There is still a need for some form of test procedures to ascertain if vehicles meet emission-control levels. General Motors foresees that perhaps in the future the emission-control system in each vehicle will be tested to determine if it meets emission-control levels.

This concludes our comments on the legislation. As your consideration of the bills develops, we will be prepared—if you so desire—to offer any technical information or any constructive comments you or your staffs may require.

In closing, we wish to reassert our earlier statement that General Motors will make every effort necessary to solve the air pollution problem insofar as automobiles are concerned.

We have a double approach: to find new ways to reduce further the emissions from the internal combustion engine, and to explore through research the potential new power sources which can be developed on a practical basis. We have committed the personnel and the funds to accomplish these objectives.

Thank you for this opportunity to discuss these important issues with you today.

(The prepared statement of Dr. Chenea follows:)

PREPARED STATEMENT OF PAUL F. CHENEA

Senators Muskie and Hart and Members of the Subcommittees, I am Dr. Paul F. Chenea. I am a vice president of General Motors and in charge of the Corporation's Research Laboratories.

With me are Dr. Fred W. Bowditch, director, Emission Control, of the GM Engineering Staff, and John D. Caplan, executive director, GM Research Laboratories.

I have been associated with General Motors Research Laboratories since June, 1967. Prior to that I was with Purdue University and the University of Michigan and served as a consultant to government, as well as industry.

We welcome this opportunity to appear today to present our views on behalf of General Motors and offer information concerning the legislation before you. We have been invited to discuss S. 3229, S. 3466 and S. 3546 as they relate to emissions from automobiles.

In addition to comments on the subject areas covered in these bills, we will address ourselves to reporting on our progress in reducing pollutants from General Motors cars and our expectations for continued progress. We already have made substantial reductions in emissions from our engines, and we expect to continue to reduce emissions in future years.

At the outset, we would like to make absolutely clear the dedication of General Motors in this matter of air pollution. We want to emphasize that air pollution problems are taken very seriously by General Motors. We are committed to doing all that is necessary in connection with the automobile to improve the quality of the environment.

As you may know, General Motors testified on two occasions during December before House groups studying the same problems that are before you today. One appearance was before the House Commerce Subcommitee on Public Health and

Welfare and the other before a panel of New York and New Jersey Congressmen.

We told the House Subcommittee—and we want to emphasize this most strongly to you—General Motors is irrevocably committed to finding a solution to automotive emission problems at the earliest possible time. In seeking solutions, we will have no hesitation in using a power source other than the internal combustion engine if it will meet the needs of our customers, at a price they can pay, and will solve the emission problem.

Our chairman, James M. Roche, reinforced his position in a letter to our California stockholders last December. He said:

"Our objective continues to be either an effective modification of the internal combustion engine or a satisfactory substitute power source. We are doing our best to accomplish this end.

"I want to assure you that General Motors is fully aware of the seriousness of these problems. We are committed to finding a solution at the earliest possible time, and we are continuing to reduce the emissions from our engines each year."

Gentlemen, these are not just words. They are an expression of General Motors recognition of the problem and our dedication to its solution. This is a public pledge of the commitment within the Corporation to seek improvements in automotive power plants—regardless of what type they may be—to solve the vehicle's part of the air pollution problem in the shortest possible time.

We are pursuing two paths to this end: (1) through finding new ways to reduce further the pollutants from the internal combustion engine and (2) exploring through aggressive research programs the alternative power sources which have potential for development on a practical basis and have low pollutant levels.

We have achieved significant progress in reducing automotive pollutants. We do not wish to take your time reviewing these accomplishments and what we expect in the future. However, for your information we are submitting with this statement an attachment that reports on progress to date and on anticipated further reductions in emissions from our cars.

RECENT DEVELOPMENTS

Since the end of 1969, we have announced developments that we feel certain will make possible even further reductions in automotive pollutants.

On February 15, we reported that all 1971 model General Motors passenger car engines will be designed to operate on unleaded fuels, as well as leaded fuel. This announcement was described by the *New York Times* as ". . . the most dramatic action by any industry in the new environmental movement."

On March 9, we announced development of a package of engine modifications and maintenance requirements that would reduce emissions of older GM cars that have no exhaust control systems. We reported details of this development March 18 to the California Air Resources Board.

We advised the Board that we can offer a used car emission control device for GM and most other California-owned cars of 1955–65 model years, if the Board certifies it for installation. This encompasses a vehicle population of approximately 5 million.

Dr. Bowditch, who is accompanying me today, gave the Board a detailed engineering report on the parts and installation requirements, adjustments and test results with 101 GM and other used cars. We will be pleased to offer a copy of his report for inclusion in the record of this hearing, if you desire.

Our tests in Detroit, Los Angeles and Phoenix demonstrated that a used car emission control package was effective in providing an approximate 52 percent reduction in hydrocarbons, 37 percent reduction in carbon monoxide and 31 percent reduction in oxides of nitrogen from previous actual operating levels.

INDUSTRY-GOVERNMENT COOPERATION

We believe that the record of what General Motors has been doing and has publicly pledged to continue doing is evidence of our concern about the environment and the need for action.

We recognize that the Congress and the Government have long been concerned about the problems of air pollution, and your Subcommittees have been particularly active in seeking environmental improvement.

General Motors welcomes joint government-industry cooperation in improving the environment. The Government has a necessary responsibility in determining suitable standards. Industry has a parallel responsibility to meet those standards.

S. 3229, S. 3466, AND S. 3546

The legislation before the Subcommittees appears consistent with this need for cooperative progress with respect to:

(*a*) Vehicle emissions.
(*b*) Stationary source emissions.
(*c*) Ambient air standards.

We have endorsed and continue to endorse the extension of the Clean Air Act. In addressing ourselves to the bills extending the Act, we would prefer to discuss subject areas raised by the legislation rather than commenting on the specific provisions of each bill. We offer the following observations in regard to the legislation:

(1) Under standards set to date as a result of the Clean Air Act, remarkable reductions have been achieved in vehicle emissions, and there will be continuing reductions.

(2) The Clean Air Act has been reasonably and fairly administered.

(3) We are in no position to judge the adequacy of the level of the financing provisions of the legislation and feel that the Subcommittees are in better position to determine this.

As to certain other aspects of the legislation before you, we offer these comments:

(1) There is still a need for some form of test procedures to ascertain if vehicles meet emission control levels.

General Motors foresees that perhaps in the future the emission control system in each vehicle will be tested to determine if it meets emission control levels.

Discussions currently are underway with California authorities to implement test procedures for that state. Extension to a national basis logically would be expected.

We suggest that the Department of Health, Education and Welfare establish appropriate standards and test procedures for the testing of the production emission control system or components. Further, we suggest that if these standards are not met, the deficiencies must be remedied.

Advancing technology now makes it possible, we think, to take approaches other than limited spot testing to ensure that each system meets such standards. Improvements in measurement techniques now permit us to achieve reasonable correlation between assembly line tests and the HEW hot cycle test. All of us—government, industry and the public—are interested in non-polluting vehicles. General Motors is endeavoring to ensure that vehicles it produces will not be polluting vehicles.

(2) We support the provision in the legislation for state inspection of emission control devices on vehicles in use.

Based on our experience, we feel that maintenance in accordance with the manufacturer's service recommendation would make a positive contribution. It was found in one survey of vehicles with control devices that adjusting the carburetor to the manufacturer's recommended settings decreased hydrocarbon emissions by 7 per cent and carbon monoxide by 19 per cent. Older cars that are not well maintained can become serious problems in terms of emission levels. A fouled spark plug could double the emission level. Therefore, we are conducting a program through our dealers to encourage proper vehicle maintenance among owners.

Inspection would identify vehicles that need maintenance. Also, inspection would tend to discourage owners from disconnecting the emission control systems on their cars, as some of them now do.

(3) We support the establishment of a national ambient air standard. This is a proper function of government. Also, it is essential, first, to determine ambient air quality desired and then, second, to set emissions standards to achieve this quality. This process, too, would give proper recognition to stationary sources as contributors to the total air pollution problem.

(4) As indicated previously in our statement, General Motors announced February 15 that our 1971 model car engines will be designed to operate on unleaded fuels. This was preceded by an address by E. N. Cole, president of General Motors,

January 14 to the Society of Automotive Engineers. He emphasized that benefits could be achieved by removing lead from gasoline.

Mr. Cole further amplified our reasoning on the importance of removing lead in a presentation March 4 and 5 before the California Air Resources Board. A copy of his report is offered for inclusion in the record of these proceedings. At this meeting, other domestic automobile manufacturers also stated that they believed that it would be necessary to remove lead from gasoline. Subsequently, the California Air Resources Board recommended to the Governor of California that they be given authority to provide for the removal of lead from gasoline.

Also, many oil companies have publicly announced their intention to have unleaded fuel available for the 1971 model engines.

We are concerned with the removal of lead only because of the need to achieve the much more stringent and desirable emission control levels of the future. Research shows that without lead in gasoline, long-life exhaust catalytic converters could become technically feasible. Exhaust manifold reactors and exhaust gas recirculation systems to control oxides of nitrogen also would have longer lives.

We wish to note that we have not advocated legislation or regulation limiting the use of lead or other fuel additives. We have simply reported that our data and research create serious doubt, as far as we are concerned, that future standards could be met with leaded fuel.

The problems of fuel composition, availability of octane pools and distribution are complex and, we believe, require the full attenion of the oil industry and presumably could be discussed more appropriately with them. However, we wish to make it clearly understood that General Motors is not in any way recommending regulation of the oil industry.

(5) Noise has long been recognized by General Motors as an environmental pollutant, and we have actively worked toward noise abatement. We have established noise control techniques and equipment in our plants and in design of our products. Further, we have worked in support of noise control legislation in California and New York. The investigation of noise levels and recommendations in the legislation regarding noise abatement certainly are desirable.

This concludes our comments on the legislation. As your consideration of the bills develops, we will be prepared—if you so desire—to offer any technical information or any constructive comments you or your staffs may require.

In closing, we wish to reassert our earlier statement that General Motors will make every effort necessary to solve the air pollution problem insofar as automobiles are concerned.

We have a double approach: to find new ways to reduce further the emissions from the internal combustion engine and explore through research the potential new power sources which can be developed on a practical basis. We have committed the personnel and the funds to accomplish these objectives.

Thank you for this opportunity to discuss these important issues with you today.

Our research, engineering and manufacturing development programs have brought about significant accomplishments in reducing automotive-caused air pollution. In fact, the record shows that the peak of automotive-caused pollution from hydrocarbons and carbon monoxide is over, as shown by charts based on HEW data on Page A–2.

To accomplish these gains General Motors has developed controls for blowby gases from the crankcase, exhaust gases from the tailpipe, and evaporation from the fuel tank and carburetor and for the three types of pollutants now identified with automotive air pollution control programs—hydrocarbons, carbon monoxide and oxides of nitrogen.

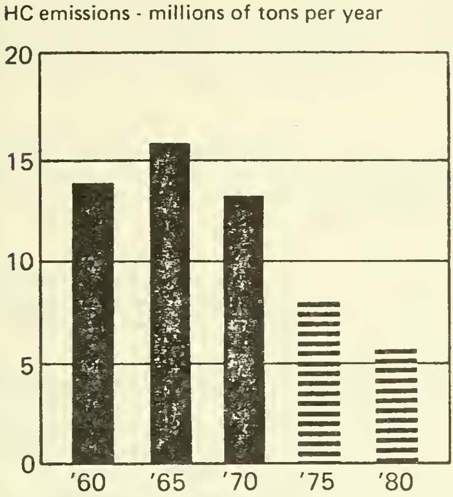
Some of the controls have been in use since 1961. The latest—to reduce evaporative emissions—are in use on our 1970 models in California and will go nationwide in 1971.

In addition, we are developing still more effective control systems for future models. The control systems developed so far have resulted in the following reductions in pollutants:

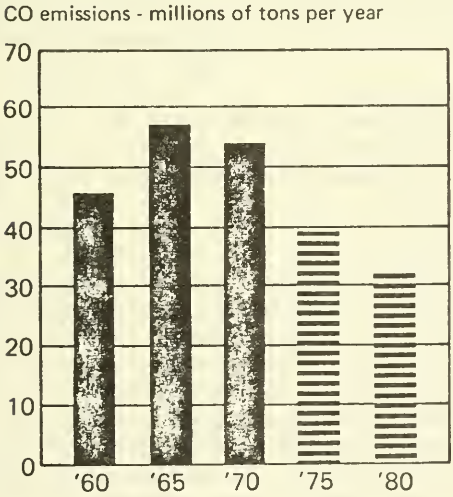
HYDROCARBONS

Since installation of the first control devices on 1961 model cars in California, the control systems on California cars have been successful in removing 80 per cent of hydrocarbons from new automobiles. It would take five 1970 model GM cars with the latest control systems to equal the hydrocarbon output of one 1960 car.

Hydrocarbon Emissions From Motor Vehicles in the U.S.



Carbon Monoxide Emissions From Motor Vehicles in the U.S.



Source:
U.S. Dept. of Health, Education, and Welfare

Carbon monoxide

Emission of carbon monoxide from new automobiles has been lowered by two-thirds from pre-control levels. Systems to control carbon monoxide were installed on California cars starting with 1966 and nationwide on 1968 models. The greatest effect of this improvement probably is being felt in congested urban areas—particularly in central city areas of our biggest cities, such as New York—where the number of vehicles during traffic peaks has increased only slightly, if at all.

Oxides of nitrogen

This pollutant has received increased attention as progress has been achieved in reducing vehicle-produced hydrocarbons and carbon monoxide. Most 1970 General Motors cars nationwide are already meeting the levels for oxides of nitrogen established for 1971 models by California.

Future reductions

New passenger car registrations account for 11.3 per cent of the automobile population, and we believe that our current and recent model automobiles, as we have just discussed, are making important contributions to reducing air pollution. What of the future?

We anticipate that the systems approach we are taking to this problem—an approach that looks at all factors—will enable us to eliminate automobile emissions from the overall air pollution problem.

Achievement of levels now being considered for 1975 would result in the elimination of 95 percent of the hydrocarbons and the elimination of 85 percent of the carbon monoxide as compared to uncontrolled cars of 1960.

To meet these objectives, our current effort is taking us into possible modification of engine design, improved control systems and possibly fuel injection for more precise air-fuel ratios.

At the same time, we are continuing intensive investigation of alternative power sources. We will not hesitate to use a power source other than the internal combustion engine if if will do the pollution control job and meet the needs of our customers at a price they can afford to pay.

We have built and tested operational vehicles powered with steam, electric, Stirling, hybrid electric and gas turbine engines and we continue to evaluate the future of these power plants in the largest research program of its type in the world.

Senator SPONG. Thank you very much.

Would either of your associates care to comment in any way on attachment A that is attached to your testimony?

We are not that pushed for time, and I appreciate very much the brevity of your statement.

Your statement certainly speaks for itself, but I would like to hear any comment you might have on this.

Mr. CHENEA. We think you might like to have your attention called, Senator, to A–2, which shows rather dramatically from the Government's own data what is actually happening in the atmosphere in this country. You will notice the chart shows that sometime between 1960 and 1970 the increase of carbon monoxide emissions from motor vehicles into the atmosphere peaked and started to decrease. There is no question about the fact that these levels are now decreasing in spite of the rising car population and will continue to decrease all through the 1970's as indicated on this chart. This data was obtained by HEW in their audit.

I might comment briefly on the effects of nitrogen oxides. This pollutant has received increasing attention and, of course, it was brought to the fore at a later date than the other two. Most 1970 General Motors cars, nationwide, are already meeting the standards for nitrogen oxides established for 1971 in California.

We believe that our current and recent model automobiles, as we have just discussed, are making an important contribution to reducing air pollution.

I would like to make one other comment, if I may, and this has to do with our decision to produce engines for our vehicles for 1971 that do not require leaded fuel. This was not done because we felt it was essential that we have unleaded fuel in 1970 or 1972. We think it is essential that we have unleaded fuel for 1975. By starting in 1971 to produce a vehicle that can run on unleaded gas, by 1975 half of the vehicles in use will be of that kind. Starting in 1971, this means that year by year we are producing vehicles that can run on either leaded or unleaded fuel and when the change does come at the appropriate time we think the car owners of this Nation will be in a much better position to adjust to it.

Senator SPONG. Thank you.

You have discussed the oxides of nitrogen. In 1967, this subcommittee held hearings in California. We were told that the equipment then being used or being subject to experiment to regulate emissions was reducing the hydrocarbons just as the chart shows, but there was a marked increase in the oxides of nitrogen. Has there been a change in the state of the art between then and now? Are we doing much better insofar as the oxides of nitrogen are concerned?

Mr. CHENEA. Yes; there has. There is no question but that some of the early measures we took to control the hydrocarbons or carbon monoxide did have an adverse effect on oxides of nitrogen.

Since this time, we have introduced additional devices which do reduce the maximum temperature of the combustion chamber and keep the oxide of nitrogen from being formed in the first place. This seems to be the most effective control and it does not unduly interfere with hydrocarbon reduction.

Senator SPONG. Prior to your testimony we heard from Mr. Blanchard of the Ethyl Corp., and you gentlemen were here when he testified. If I understood his testimony, he said that taking the lead out of gasoline would reduce the hydrocarbon emissions and would reduce the oxides of nitrogen, but would increase the carbon monoxide emissions.

He also testified that photochemical smog would be increased. He used a figure of 25 percent and then quoted an official of the Bureau of Mines to the effect that the figure went up to 38 percent.

I was not present for all of the testimony of the Ford officials, and I asked a very brief question about the effect of lead removal on smog. I would ask if any of you gentlemen would care to comment on that.

Mr. CHENEA. Be very glad to, Senator.

The reasoning which was presented by Mr. Blanchard is based on two premises: One, that taking the lead out of gasoline will reduce the fuel economy, and it does—very slightly. More importantly, it was based on the premise that the octane rating would be maintained by the addition of some other component, probably aromatics. Under these two circumstances you do get an adverse effect. However, this adverse effect need not take place, because we have reduced compression ratios on our proposed 1971 engines to permit them to operate on lower, or 91 octane gasoline, which is about where the octane rating would be if you took the lead out of premium gasoline and did nothing else to it.

Senator SPONG. Ninety-one octane?

Mr. CHENEA. Ninety-one octane is the figure for which we are designing, 90 to 91. This is slightly below regular gasoline today.

Senator SPONG. We thank you gentlemen very much for your testimony and for being here.

Mr. CHENEA. Thank you for inviting us.

(Additional materials, supplied later, follow:)

STATEMENT OF E. N. COLE BEFORE THE CALIFORNIA AIR RESOURCES BOARD AND ITS TECHNICAL ADVISORY COMMITTEE*

Chairman HAAGEN-SMIT. We have now come to the presentations by the representatives of the automobile industry, and No. 1 on the list is Mr. Edward N. Cole, President of General Motors. Mr. Cole.

Mr. EDWARD N. COLE. Thank you, Dr. Haagen-Smit.

General Motors representatives are happy to respond to Governor Reagan's invitation by being here this morning to discuss the relationship of engines and fuel in controlling emissions. We believe we can be most helpful to the Air Resources Board and the Technical Advisory Committee if we cover three basic points:

First, a brief technical summary of the effects of gasoline on emissions control; and

Second, an outline of General Motors' current plans concerning future engine modifications which depend on fuel availability to meet these plans; and

Third, a list of possible areas of regulatory action by the Air Resources Board which we believe the Board may wish to explore.

While the announced purpose of this meeting is to discuss prospects for improving the quality of air in California through fuel composition and emission control, I want to give you and Governor Reagan my personal assurance that we at General Motors are directing our attention to all aspects of the overall emissions problem. In addition to our various research and development programs directed toward improving the internal combustion gasoline engine, we are continuing to work on several potential alternate powerplants.

I want to emphasize that we are not wedded to the internal combustion engine. We would not hesitate to replace it if we could find a practical alternate source of power which could take us to lower emissions levels than we can reach by controlling the internal combustion engine.

As to the specific subject matter of today's meeting—results of our research programs into the relationships between fuels and engines indicate there are strong reasons for having unleaded fuels available in ample quantities as soon as possible.

In our opinion, there are a number of aspects of fuel composition which affect emissions from spark-ignition gasoline engines and which deserve consideration. These are:

1. Lead Alkyl Additives;
2. Aromatic Hydrocarbon Components;
3. Olefinic Hydrocarbon Components;
4. Volatile Hydrocarbon Components;
5. Detergent/Dispersant Additives; and
6. Gaseous Fuels.

Now, I should like to direct my attention to the first item, the *Lead Alkyl Additives.*

Our research indicates there are several problems which result from the presence of tetraethyl lead in gasoline:

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*The copy for Mr. Cole's statement submitted by General Motors for inclusion in this record consists of the following pages from the official transcript: Volume I, March 4 statement and questions—pages 13 to 39 incl.; Volume II, March 5 supplementary statement and questions—pages 10–33, 60, 97.

Item (a) Lead emissions to the atmosphere.

We are not medical experts, but we recognize there is considerable concern among health authorities as to the possible effects of lead on human health. Removing lead from fuels would relieve some of that concern. It would also greatly reduce the total emission of particulates from automobile engines and go a long way toward meeting the indicated HEW particulate emission requirements. We know of no way to meet that goal with lead compounds in gasoline.

Item (b) Catalytic exhaust treatment

Reduction of hydrocarbon and carbon monoxide emissions to about the 1975 California standards appears technologically feasible with catalytic exhaust treatment, provided only unleaded gasoline is used. We know of no catalyst at this time that has a reasonable lifetime with leaded fuel. There is evidence that even one-half gram per gallon renders the catalyst ineffective in a relatively short time.

Item (c) Manifold reactors

Another approach which might be required to meet 1975 California standards is the use of an exhaust manifold reactor. Attack of lead salts in exhaust gas on ceramic-lined manifold reactors has been demonstrated. The well-documented lead attack of stainless alloys at high temperature, and low temperature corrosion of stainless steel by lead halides, are expected to be problems with metal reactors. Elimination of lead should improve the durability of either metal or ceramic reactors.

Item (d) Exhaust recirculation systems

Exhaust recirculation systems appear to be necessary to achieve the required further reductions in nitrogen oxide emissions. During the testing of experimental systems developed by General Motors, severe deterioration has developed with mileage accumulation due to the deposit of lead salts in the recirculation tubes and orifices.

Item (e) Hydrocarbon oxidation

Experimental data indicate that removing lead from gasoline gives us a direct reduction in hydrocarbon emissions on the order of about 20 parts per million, even on brand new cars. This comes about through natural oxidation of hydrocarbons in the exhaust gas—a process which apparently is seriously inhibited by the presence of lead.

Item (f) Lead effect on hydrocarbon emissions

Lead also inhibits hydrocarbon reduction on cars which have accumulated mileage, through the build-up of leaded deposits in the combustion chamber. Experimental evidence from many laboratories, using many different cars and driving conditions, indicates a reduction of between 40 and 100 parts per million hydrocarbons from cars without emission control systems by the elimination of lead from gasoline used during mileage accumulation.

Item (g) Octane requirement

The octane requirement increase with mileage accumulation appears to be approximately one to two octane numbers less with unleaded gasoline than it is with leaded gasoline.

Item (h) Exhaust system corrosion

Laboratory tests of muffler steel subjected to exhaust condensation indicate a doubling of life with unleaded gasoline.

Item (i) Crankcase oil performance

Laboratory and field test results indicated considerably improved rust protection in engines operated on unleaded gasoline. Crankcase oil drain intervals longer than the present four months appear feasible with unleaded gasoline.

Item (j) Spark plug life

Lead fouling in spark plugs leads to drastic increases in hydrocarbon emissions in cars in customer service, and is the basic cause of spark plug replacement in the field. Phosphorus additives are used in some present gasolines to reduce spark plug fouling. Without lead deposits, spark plug life would be increased, and the phosphorus additive would not be needed.

Now that pretty well concludes the statement I would like to make about the lead effect, and now I would like to discuss some of the other characteristics of fuels that also affect the emissions, and the first item which is the second item of the total is:

Item 2. Aromatic hydrocarbon components

Our research disclosed that another aspect of fuel composition which is significant from an air pollution standpoint is the presence of aromatic hydrocarbons. They are of concern for two reasons. First, the carcinogenic polynuclear aromatic hydrocarbons, such as benzo(a)pyrene, which are present in some commercial gasolines, have been found to pass through the engine combustion process and appear in the exhaust gas.

During our smog chamber test another problem developed with aromatic hydrocarbon components in gasoline due to the tendency for certain aromatic hydrocarbon molecules to form a potent eye irritant when passed through the photochemical smog reaction. We would like to suggest that a close look be taken at the aromatic composition of gasolines to see if there can't be some selective elimination to ease the eye irritation aspects of photochemical smog. We realize that aromatics are very important to octane quality and would normally tend to increase whenever an effort is made to reduce volatility, or olefin content, or to eliminate lead while maintaining octane quality.

Item 3. Olefinic hydrocarbon components

The volatile olefinic hydrocarbon components in gasoline tend to make the evaporative emmissions photochemically reactive, and olefin removal is an alternative to volatility reduction for decreasing the smog effects of evaporation losses on cars without evaporative emission control hardware. The same reduction in smog potential can be obtained by reducing olefins as by lowering volatility. Since it appears that the olefin removal route may be more attractive than severe volatility reduction, our research indicates that the C_4 and C_5 olefins could be eliminated from summer gasoline in Southern California. This could be effective on both new and used cars, and should give a reduction in total vehicle hydrocarbon emission reactivity on the order of 10 percent for pre-1966 model cars; 20 percent for 1966 to 1969 model cars; and about 2 percent for 1970 and later model cars with evaporative control systems.

Item 4. Volatile hydrocarbon components

The volatility of summer gasolines is represented by an average Reid Vapor Pressure of about 9.2 pounds per square inch and a range of 6.0 to 12.0 pounds per square inch. If the Reid Vapor Pressure of summer gasoline did not exceed a maximum of 9.0 pounds per square inch, there would be about a 20 percent reduction in evaporative emissions, on the average, for 1950 to 1969 model cars. For 1970 and later model cars with evaporative emission controls, the absolute reduction in evaporative losses would be very small, but such a limit would help greatly to avoid some of the problems which have been found to be very troublesome with the new evaporative emission control hardware under severe high-temperature conditions. These hardware systems were designed using the 9.0 pounds per square inch Reid Vapor Pressure fuel specified in the California test procedure. Less variation in volatility among gasolines at a given time would aid in providing more precise fuel metering with consequent improvement in emission control.

Item 5. Detergent/dispersant additives

General Motors believes that the use of detergent/dispersant additives, to prevent deposit formation in carburetors and intake systems of engines, as well as general engine cleanliness, could be helpful in reducing deterioration of emission control systems.

Item 6. Gaseous fuels

General Motors believes that although liquified petroleum gas and natural gas may have potential for use among fleet operators and in special situations where carbon monoxide pollution is particularly significant, these gaseous fuels are probably inappropriate for use by the general public because of serious problems of limited distribution and supply.

These conclusions as to gasoline properties are supported by data from tests conducted by General Motors and by a number of others. As we understand it, the basic purpose of this meeting, as outlined by Governor Reagan, is to discuss only one of those properties of gasoline—the use of tetraethyl lead—and our remarks will now concentrate on that subject.

If the Air Resources Board concludes that use of an unleaded gasoline will accelerate solution of the Air pollution problem in California, we are confident that the Board will take whatever action it finds to be necessary to accomplish this objective.

The Board may be assisted in its deliberations if we summarize General Motors' present intentions in terms of future time periods.

First—As we announced in a press release on February 15, engine design of all 1971 General Motors cars is being modified so that they will be able to operate satisfactorily on unleaded gasoline at about 91 Research octane number. If unleaded fuel is not available, they may be run on currently available leaded fuel. However, use of unleaded gasoline would reduce hydrocarbon emissions, and have other benefits, as described previously.

Several petroleum companies which distribute fuel in California have publicly announced that they plan to produce unleaded fuel in the near future. The use of unleaded gasoline will reduce emissions not only from 1971 GM cars, but also from earlier GM models as well. We believe that many pre-1971 GM vehicles now in service *which use "regular" grade gasoline* will be able to use 91 Research octane *unleaded* gasoline. Some of these may require minor adjustments to obtain satisfactory operation. In the case of pre–1971 GM high compression engines *now using "premium" grade gasoline,* our preliminary studies indicate that many could use a 97 Research octane *leaded* fuel, again with minor adjustments to some engines.

Our reasons for proposing Research octane numbers of 91 and 97 can be stated very briefly. For many cars now using regular gasoline, it appears that 91 leaded or unleaded is the minimum which would be practicable. Also for cars now using premium fuel, it is believed that GM cars requiring 100 octane leaded fuel could use 97 octane leaded fuel by making minor timing adjustments to the ignition system. These octane numbers reflect our own thinking. We assume that other vehicle manufacturers and the oil companies will comment on this point.

Beyond the immediate benefit of using unleaded gasoline, we are making these changes on our 1971 models to achieve these benefits at the earliest possible time so as to reduce the number of vehicles in the car population in 1971 and thereafter which require leaded fuel.

So far we have shown that the earlier in the 1971 model year unleaded gasoline becomes available in California, the quicker there will be some further improvement in air quality. For the 1972 model years, however, this becomes more than a matter of desirability. General Motors research indicates that unleaded fuel, of a suitable octane number, will be required in California by September 1971, in time for the introduction of General Motors 1972 model cars, in order that emission control systems can function properly.

Second, in our series of steps—The more stringent California standards, which will become effective with respect to 1972 model years cars, necessiate changes from the 1971 model emission control systems. In testing prototypes designed to meet California 1972 requirements, we are finding that lead deposits are causing such rapid deterioration of some of these devices as to make them unworkable in some respects, so that such cars might not be approved for sale in California. Also, preliminary indications are that, even in a system which would qualify for approval by the Board, the use of leaded gasoline would cause hydrocarbon emissions to increase materially while the vehicle is in service.

Third—General Motors has underway an intensive program to select emission control systems which are substantially different from, and more complicated than, those presently in use. We are hopeful that these new systems can be developed to a point that in time they can be incorporated into some General Motors cars prior to the 1975 model year, although it is too early to make definite predictions.

Our research indicates that these new systems we now have under development should have unleaded gasoline available to operate efficiently. For example, an important part of one of these systems may well be a catalytic converter. Our data indicate that satisfactory operation of a catalyst can be achieved only with unleaded fuel.

Therefore, in the light of all the preceding facts, General Motors believes it is clear that action regarding the properties of gasoline is urgently needed. We believe that the benefits to be derived from altering the existing gasoline properties are so substantial that promptness will be very much in the interest of California citizens.

In summary, General Motors suggests that the Air Resources Board consider means of achieving the necessary gasoline specifications which would provide the following:

(*a*) A grade of unleaded fuel suitable for past-model regular-gasoline cars, generally available not later than September 1971 and as much earlier than that date as is feasible.

(*b*) A grade of fuel suitable for past-model premium-gasoline cars, leaded if necessary.

(*c*) Control of additives other than lead at suitable levels, in the light of the foregoing discussion.

(*d*) Control of volatility and other properties consistent with needs to reduce smog.

In addition, the existing regulations concerning approval of emission control systems should be revised to provide for the use of gasolines meeting the new unleaded specifications.

And finally, the Air Resources Board should consider whether action is necessary to insure that leaded gasoline is not used in the new vehicles which are designed to operate on unleaded fuel, and again this is extremely important as indicated by Dr. Haagen-Smit. Obviously, if motorists driving those cars continue to use leaded gasoline, the benefits of the design changes will be lost.

General Motors believes that prompt and effective action with respect to gasoline properties, as broadly outlined in this statement, can contribute in a major way to the reduction of air pollution from automobiles. We are prepared to cooperate with the Air Resources Board and the Technical Advisory Committee to accomplish this goal. Thank you very much.

Chairman HAAGEN-SMIT. Thank you, Mr. Cole, for your statement. Would members of the Board and Technical Committee like to ask Mr. Cole any questions? Dr. Starkman.

Dr. STARKMAN. Mr. Cole, you have answered many questions in your direct presentation today but by answering many question you raised a few others. Do you visualize that going below 91 octane number with an unleaded fuel could be of benefit in decreasing emissions from motor cars as time goes on?

Mr. COLE. No. Do you want me to give you a technical reason?

Dr. STARKMAN. Please.

Mr. COLE. We feel that as you go down in compression ratio—of course this is associated with octane requirement—and you are familiar with the thermal efficiency curve with compression ratio and there is decreasing benefit as you go higher in compression ratio much above 8½. There is some benefit, and if you are concerned with economy, efficiency and performance, you do get some benefit, but as you go higher in compression ratio you require higher octane fuel. At the same time those higher ratios basically have higher pollutant emissions both in oxides of nitrogen and unburned hydrocarbons. So there is a point, however, as you go down into the trade off area where the efficiency, the performance and emissions are at about a stand-off on this trade off as we see it, and we think we can develop control systems that are adequate to control whatever emissions are left in the system, say, with the 91 unleaded fuel satisfactorily down to the point of, we say, essentially pollutant free.

Dr. STARKMAN. Thank you. Did I read into your statement that you have in mind about an 8½ compression ratio?

Mr. COLE. Yes, sir, about 8½ is where it will fall, and that depends, of course, upon many things, depends upon valve timing, the particular type of engine, the intake system and others, but 8½ is a good round number.

Dr. STARKMAN. Another question—you said on existing cars a simple adjustment to timing would aid them to accommodate themselves to lower octane fuel. What do you mean by simple, a retard or a modification?

Mr. COLE. Well, just a retard if you are familiar with the phenomena. By retarding the spark about 1 degree you pick up one octane number, and if you go back far enough you will remember that Chevrolet at one time had a device on their ignition system known as an octane selector, and you simply set the ignition at a level to match the knock rating of the fuel that was available, and this is a rather simple operation, and we feel it is quite satisfactory and the benefits to be derived from this are a lot greater than the loss in efficiency or in economy.

Dr. STARKMAN. And the final question—you said there is going to be a breakover in 1972 and lead in gasoline would make the job a lot harder, paraphrasing what you said.

Mr. COLE. Yes.

Dr. STARKMAN. I presume that is because you have in mind the exhaust recycle?

Mr. COLE. Yes, some of that, but on the other hand the regulations are becoming more stringent and there are two elements increased in the standard. One is the requirements for every vehicle off the production line to be tested and meet the requirement as opposed to the prototype in the past procedure of being certified. So every car that comes into the State of California we plan to run its characteristics, its pollution characteristics, at the end of an assembly line. Therefore, there is about—we have identified approximately 60 parameters in the whole design that affect emissions, and so what we must do is to have more leeway and have tighter in-house standards to insure that all of our cars will pass these very very stringent tests and that this is why we say, this isn't just a movement of the standard from where you are today to a new standard. It is a movement in process as well which causes a much tighter performance on the part of the manufacturer.

Dr. STARKMAN. Thank you.

Chairman HAAGEN-SMIT. Dr. Heslep.

Dr. HESLEP. Mr. Cole, you made a persuasive case about the desirability of having unleaded gasoline available in California in 1971. Would you care to comment on the other side of that question, namely, what if legislation were adopted that would phase out lead in gasoline in California, say over the next two or three years, would you care to comment on what this might mean in terms of pre-1971 General Motor cars?

Mr. COLE. Yes, I would be glad to comment. It is our opinion, you see, currently the premium fuel octane is approximately 100. And we use about 3 milliliters of lead or 3 grams of lead per gallon. Now, going down to 97 you have some depression in the performance, and we plan to accomplish that difference through a minor adjustment in the ignition timing.

Now, to reach all the way from the 97 down to 91 would take some other changes besides the ignition changes and very likely require a reduction in the compression ratio to accomplish, and this could be a massive change and tremendous effect upon those people that do own cars that have this higher compression ratio that would need, say, the 97 octane fuel.

Chairman HAAGEN-SMIT. Mr. Chass.

Mr. CHASS. Mr. Cole, you recommend that the lead C_4 and C_5 olefins be removed from gasoline. Would you then recommend that the State place a maximum on the aromatic content?

Mr. COLE. Well, this is a very delicate subject and it gets into the technical aspects of this whole discussion, and we say primarily C_4 and C_5 are in the evaporative area, and as emission control systems are advanced with the evaporative control—this is prior to the fuel being used in engines. In the transfer of the fuel the losses through the carburetor loss, through the fuel tank, of course, and that type of thing—by taking C_4 and C_5 olefins out you do reduce the eye irritant components, and I would like to have Dr. Agnew comment on that perhaps a little further. He runs the smog activities of our general research laboratory, and I think he could enlighten you perhaps further in this area. Dr. Agnew.

Dr. AGNEW. I think the point here is the C_4, C_5 olefins elimination would assist in the reduction of reactivity of evaporative emission. Now, whether there is a need to counteract the elimination of C_4 and C_5 olefins by an increase of aromatics is an entirely separate question. I think this might not be required, but in any case the situation with regard to aromatics is that the composition of aromatics and amount of aromatics in gasoline should be watched very closely because increases in certain aromatics in the gasoline could increase air pollution problems, so that while we recognize there are other things in the gasoline, I think we just want to make sure that the deleterious aromatics are not increased in gasoline and counteract this effect as far as the atmosphere is concerned. Aromatic levels today might be all right, but perhaps again selective elimination of certain of these aromatics could improve the atmosphere with regard to the eye irritation and carcinogenic materials.

Mr. CHASS. If you removed both the lead and C_4 and C_5 they would be replaced with something; what would you recommend they be replaced with?

Mr. COLE. If the lead is removed and the octane requirement is not raised back up to the original levels of 100 octane for premium gasoline, for instance, then there may be no need to increase aromatics.

Mr. CHASS. Then you believe that the 91 octane can be reached without lead and without the C_4 and C_5 and without increased aromatics?

Mr. COLE. To a large extent, yes.

Chairman HAAGEN-SMIT. It is also possible to screw the emissions in hydrocarbons down two notches?

Mr. COLE. I think just to comment further on this subject, this is a very delicate balance and something that we need to know more about, and as we indicated, if we have adequate control of the evaporative losses which we are talking about here, then we have more freedom in the aromatic field, and we probably won't need, I believe, to modify the C_4 and C_5. If we could transfer the fuel all the way through to the engine, carburetor and in the engine and out, then I don't believe the C_4 and C_5 would be a problem, is this correct?

Mr. CHASS. One more question—would you object to having a maximum set on the aromatic content, a maximum aromatic content on gasoline?

Mr. COLE. I would like to have Dr. Agnew comment on that. This again gets into an area of the refiner with his various stocks available to him and other problems that are not in the province of General Motors, and I think the best answer to it is we would like to have 91, say, unleaded fuel with an average of 9 pound Reid Vapor Pressure, and if we could have aromatics that wouldn't cause us problems in the eye irritant area, we would be happy.

Dr. AGNEW. Well, I would add just one point. I don't think we would have any objection to elimination in aromatics from a technical standpoint in the operation of the engines. If it is felt that some increase in aromatics is required to reach these octane levels that we want down the road in the future, I think we should be selective about the aromatics. I don't think necessarily we have to say that all aromatics should be eliminated. Some aromatics may be all right, but we have to be selective about any increases in aromatics that are made in the future.

Chairman HAAGEN-SMIT. It is just the question of price, isn't it? If you have benzene, you'd be all right, but an alkylated benzene would get you into difficulty.

Dr. AGNEW. That is right. So really, you are going to have to ask the oil refiners, I think, what their economies are with regard to aromatics and octane requirements in the future. In any case, watch the composition of aromatics.

Chairman HAAGEN-SMIT. Dr. Cattaneo.

Dr. CATTANEO. These statements about aromatics seem to imply that the catalytic converter at the end of the exhaust line does not do as good a job as on the other hydrocarbons, is that a fact?

Mr. COLE. I think what we are talking about are those vapors that escape the system before they go through the engine. They are evaporative losses, so really it has nothing to do with that technical problem that you raise.

Chairman HAAGEN-SMIT. Mr. DeHaven.

Mr. DEHAVEN. Mr. Cole, if anti-pollution devices are designed for non-leaded gas for use in California and if lead does indeed nullify—what would happen to cars that leave the State for a certain period and then come back where leaded gasoline is the only fuel available?

Mr. COLE. This would represent a problem, no question about it. And how many of those cars would be involved, we are going to have to—as far as we are concerned get some understanding of the kind of requirement and notify the owner of this car in order to meet the California requirements for pollution control that unleaded fuel will be necessary. Now, how this is handled, this is something for future discussion and possibly for the Board and the Technical Committee to consider, and we have looked at it. Of course, what we would like is to see this kind of fuel become generally available throughout the country at the same time and that would be a very quick answer to the problem.

Chairman HAAGEN-SMIT. Mr. Schmid wants to ask a question.

Mr. SCHMID. I wanted to ask you, Mr. Cole, in view of the fact you reduce compression ratio, you naturally reduce the horsepower output, do you not?

Mr. COLE. Yes, sir.

Mr. SCHMID. And in order to continue with your efficiency and, of course, what we are considering a high speed automobile, would you then necessarily increase the cubic inch content of your motor in order to offset that loss?

Mr. Cole. No, these changes are rather insignificant, and it is doubtful that any of the Board or the Technical Committee could observe them either as to performance or perhaps economy. In fact, we have as much differences between cars that are supposed to be the same as the differences we are talking about, and I would like to make this very clear that the reduction in compression ratio on our regular fuel cars is insignificant. It is approximately the same, so there is no change in performance or economy on those cars that are now designed for regular gasoline, and the change comes for those cars that are using premium fuel. For example, a Cadillac is around the 10 to 1 compression ratio, and we plan to go down to about 8½ to 8.7. Now, this will cause some reducion in performance, but it will be rather insignificant. Now, you could recover that performance and if you wanted to do this by simply changing the axle ratio and that gives you, in effect, more displacement without changing the engine, but then you would probably lose further economy, but I believe we will be demonstrating to the press and others these changes in this effect on performance and economy in a short time and it is not significant.

Chairman Haagen-Smit. Dr. Pitts.

Dr. Pitts. Mr. Cole, in addition to the reduction, let's say, in hydrocarbons that might come about while using non-leaded gasoline, I am curious to know what your studies have shown in the effect on the formation of aldehydes, the emission of aldehydes from exhaust. As you know, on certain modes the seven cycle, California cycle, one particular mode going from 10 to 50 and on light acceleration aldehydes might be as important a contaminant as hydrocarbons.

Mr. Cole. You have the same in thermo pollutions. This is another problem.

Dr. Pitts. As you go from leaded fuel to nonleaded fuel have your studies shown an increase in aldehydes, a decrease in aldehydes or are they unchanged?

Mr. Cole. I think I will defer that question to the technical experts.

Dr. Pitts. I realize it was a bit loaded rather than leaded. I am concerned about the oxides. The Advisory Committee, as you know, is concerned about not only the hydrocarbons, but these are partially oxidized, and what really comes out is what is important to the person on the street. Is he being assaulted by aldehydes not only from photochemistry but from the direct emissions?

Dr. Agnew. I think, as you probably know, the status of the knowledge of aldehyde emission from engines is not very good at this stage primarily because of difficulties in measurement techniques with aldehydes. However, the indication we do have is lead compounds in the exhaust are an inhibitor of the oridation reactions which are occurring naturally in the exhaust system, and when we take the lead out we find that these oxidation reactions proceed more easily. We would not expect from that then that aldehydes would increase as a result of lead removal.

Dr. Haagen-Smit. We certainly will go to testing of the aldehydes on a large scale because the closer we come to the 1976 low standards the more important the testing of aldehydes becomes, so we certainly will look into this, and I am glad you will look into it too.

One more question from Dr. Seymour Calvert.

Dr. Calvert. Mr. Cole, what would be the significance of using unleaded gasoline on past model automobiles, say, besides reducing particulate emissions?

Mr. Cole. Well, I indicated in my discussion that our reserach and tests have shown that there is an immediate effect of from 40 to 100 parts per million of reduction in the emission, hydrocarbon emission, simply because of the inibition of the oxidation process that lead produces even in the exhaust system, so we would expect—we said 20 parts per million in the brand new car without deposits, and then as the car accumulates deposits our tests have indicated and others have indicated as much as from 100 parts per million and proven on the existing cars with no further change.

Dr. Calvert. Is this due to the removal of the lead deposits?

Mr. Cole. No, the lead deposits are not removed, but the lead in the combustion process does inhibit the complete chemical exchange of your unburned hydrocarbons into components that are less desirable.

Dr. Calvert. This is independent of the State of the pistons and so on.

Mr. Cole. I think you can liken it to this, that the lead that holds and retards the combustion process to inhibit knock or spontaneous combustion is the same thing. It tends to limit the complete reaction of unburned hydrocarbons in the exhaust system, the complete oxidation.

Dr. CALVERT. Another related question—are you planning to have made available any add-on emission systems, exhaust emission systems, which would be made feasible by non-leaded gasoline?

Mr. COLE. We are working on this and we expect to report it to the Board very shortly and we have very fine success with this approach, but it is not related necessarily to the availability of unleaded fuel. However, the unleaded fuel does add to the benefit, and we feel that through the system we are talking about we could accomplish a massive improvement in the air quality over Los Angeles in a relatively short time if the car population currently on the road could be retrofitted and we are hoping to do this for a very nominal price, and if this can be accomplished, it should make a massive improvement in a hurry in this area.

Dr. HAAGEN-SMIT. Thank you, Mr. Cole. I have just one more question. If you reduce the compression ratio would the oxides of nitrogen go down too without even discussing the lead?

Mr. COLE. Well, there is quite a lot of discussion on this, but just to use some round numbers, taking a compression ratio of 10 to 1 down to 8 to 1, we get reduction in that process around 28 percent reduction in hydrocarbon and about 23 percent reduction in oxide of nitrogen, and so by lowering the ratio you automatically reduce the pollutant level of the natural process, and some of this is due, we feel, as you go into higher compression ratios we pack more of the gas, combustible gas, into the crevices, and then this gas, because it is quenched cannot react or burn. By lowering the compression ratio you have less of this gas that is in those crevices and those areas like the top of the piston and around the valve and places of this type, so this is a natural phenomena that it does help, and then on oxides of nitrogen it is a matter of peak temperatures, and as you drop the compression ratio, you drop the peak temperatures of the combustion process.

Chairman HAAGEN-SMIT. Thank you very much, Mr. Cole. I am sorry I have to interrupt this. We would like to keep you all day.

Mr. COLE. Thank you.

Chairman HAAGEN-SMIT. But we have a schedule. I said that maybe we should be here all evening. Maybe we should bring our sleeping bags with us.

The next speaker is Mr. John Adamson, Vice-President of Engineering and Research, American Motors Corporation.

Mr. ADAMSON. Mr. Chairman and Members of the California Air Resources Board and Technical Advisory Board. My name is John F. Adamson. I am Vice-President of

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perhaps the best way to do it would be to pass me a note. I see Howard Hesselberg. I will put you down next in order.

Would you please in approaching the speaker state your name and affiliation. We probably know who you are. I am sure we all know who the gentleman is sitting at the speaker's table.

Mr. COLE. Thank you, Dr. Starkman. I am Edward N. Cole, president of General Motors Corporation, and the purpose of the request is to clarify some of the positions that we have taken in this very critical area of the relationship of engines and fuels and what in my opinion were some misquotes of that position in yesterday's session, so I would just like to briefly review what our position has been so that the Board and the Committee will completely understand what we have said in the past and how this whole program from our point of view got under way.

On January 14 of this year we presented—I presented a paper to the National Society of Automotive Engineers in Detroit indicating that it appeared to us that as we viewed the future emission control standards, the ones that were given to us in Washington and earlier in December by HEW undoubtedly would require removal of lead in order to meet those standards. We did not take a firm position saying lead had to go. We simply said from our data and our research it indicated a serious doubt in our minds that those standards could be met if lead was continued in the fuel.

Then on February 15th we announced that all General Motors cars for 1971 would be so designed and modified that they could operate successfully on 91 unleaded or leaded fuel or the fuels that are presently available, and again the purpose of that position was to try to phaze out those cars that would be needing the higher octane fuels leaded or unleaded as early as possible from the car population.

Then yesterday on March 4th we said that we might need unleaded fuel in California for 1972 models in order to meet the 1972 California emission standards.

And we also indicated in our presentation. and that was the presentation and the statement I made yesterday, that GM cars built prior to the 1971 models would have reduced emission if unleaded fuels were used, and we also indicated that it was very likely that minor ignition adjustments would be necessary to some cars in the population to operate on the lower octane of 91 leaded or unleaded and 97 leaded fuel.

Now, since it is our responsibility, as we see it, to see that our cars in the 1972 model year meet the more rigid standards in California and further tightening of emission standards by 1974, in addition to the changes in test procedures for certification, we certainly recommend consideration be given to a modification of the presently available fuel.

Therefore, I would like to review for the Board and the Technical Committee some information we have available that was not presented yesterday for the reason that the projection facilities we thought would cause you some inconvenience but today we think maybe we can inconvenience you a little bit, so we would like to first show the 1972 through 1975 proposed standards so that we all have an understanding of the position we are taking, so if I could have the first slide to show what those standards actually are.

What I would like to point out, these are the emission requirements as we know them, and of course, you are familiar with the prior control 1966 was 3.4 HC and 34 grams per mile of CO, and then we will move on over here to the 1971. You see there is movement down in hydrocarbons and a movement down in CO and there is a new standard, and this is the one we are concerned about currently, but we feel we can accomplish and that is the oxides of nitrogen requirement, and we have, of course, the evaporative control requirement.

Then in '72, we move down 25 per cent on this control, so this is the area we are concerned with and still we have the evaporative loss concern.

And then in 1974 there is a further movement from 3 down to 1.3. These two—hydrocarbons and CO stay the same, but then we come along to federal standards, and you will find that the federal standards track along here pretty well with the California standards and then through 1971, and here is the first time that we have seen a particulate standard of 0.3 grams per mile of particulate. That goes in the first time on a national basis in 1971.

Now, here is one we are concerned about, and this is why we have got to prepare ourselves with more sophisticated equipment in order to make these standards. If you will notice they're about the same as a half gram per mile on hydrocarbons against 6-tenths of a mile here, 12 against 11½, 1 against .95, and then you see evap control here and here, and here is the one that we are concerned about on particulates. This goes from .3 down to .1, and in California I don't know what happened—you kind of missed this one maybe. But the Federal is upstaging you a bit requiring particulate control.

Now then, as you move forward these get progressively tighter, so I wanted you to understand, if we could, the progressive tightening of these standards and why we are going to have to step up to the problem with some more sophisticated equipment in order to arrive at this point.

Now, this is 1975 year, you say, because as far as we are concerned, this is the middle of 1974 as far as our equipment is concerned, so our lead time is roughly about 30 months to accomplish this objective, so we must know right now what kind of fuels we are going to be using in this area. So much for that. The next slide, Bill. I want to be sure everybody is quite clear as far as that one is concerned.

Now, the concern we have in catalytic area and we feel it is very likely that the catalytic treatment of exhaust gases is a good possibility and as far as the operation of catalysts are concrned, we have run catalysts in cars on the road 50 to 60,000 miles and their performance at the end of this period was equally as good as when they started, and this was on unleaded fuel, so we don't have any fear that the catalysts can be made available that will be successful, but to give you an idea of the effect on catalyst performance, and here is hydrocarbons with parts per mile with leaded fuel, and here it is with lead-free fuel. I don't think I need to talk much more about this slide to give you an indication of the poisoning effect that lead has on the catalyst approach to treatment of fuel.

Now, this is a curve that you saw yesterday, but I just wanted to bring it back and talk about this in a little different detail and that is roughly 3 grams per mile, about where we stand now on both regular and premium fuel, and as we move back, this is the effect of lead on catalyst life, and if you will notice this is a half life for the catalyst in miles. So if we use the catalyst approach and even go down to half a gram, you see the mileage, although reasonable, it is short and it may be that that would be satisfactory in light of what it does, but we don't feel that 15,000 is adequate. We would like to see a catalyst be effective in the area of 35 or 40,000 miles minimum. Next slide.

If there is any question on these slides you would like to bring up while we are going through——

Now, here is some information we would like to clarify again, and this is the effect of deposits on hydrocarbon emissions in that happens to be a Chevrolet 307 cubic inch engine. This is in new condition and this is 13 cars run on leaded fuel and this is new condition. It increases in deposits to a point and emissions for 103 parts per million or 49 per cent.

And then simply from dirty to clean by removing the deposits we go down 98 parts per million and only a reduction of 43 per cent, so you can see the effect of deposits on emissions, and these are lead deposit effects.

Unidentified Speaker. Were these mechanically cleaned or were they cleaned by running clear fuel?

Mr. Cole. These were mechanically cleaned by taking the head off and taking the carbons and dirt out. Next slide.

I think this is quite important because we said that the unleaded fuel had an immediate effect on the reduction of unburned hydrocarbons and here is leaded fuel run 956 miles in this car with the increase in hydrocarbon emissions of 71 parts per mile or 34 per cent. Now, this is an Amoco fuel which is available and happens to be 20 per cent of the output of fuel made by American Oil Company, and this increase is only 4 per cent or 8 parts per million, and this is exactly the same car just run right after that with the same equipment and also only run a thousand miles roughly, so I think this demonstrates as far as we are concerned the lead effect alone on emissions.

Here is another dramatic curve that we wanted to show you. We ran these cars and they are two cars we ran out here to about 21 or 22,000 miles and we had constant emissions and this is no lead, and both of these cars—one car with no lead and no detergent dispersant and this is no lead plus detergent dispersant.

Now here apparently there wasn't anything for the detergent dispersant to clean out of the carburetor. That tends to improve the emission so far as we are concerned. These two are identical cars and then we simply added lead without the detergent dispersant and you can see what immediately happened to the emissions, and then we came out here and took the lead out and we started to fall immediately. And this is the effect we say on cars that are now on the road that have been running on lead that when lead is removed you can expect some improvement in the emissions. This is with the detergent dispersant and it went out this way down here. We got a slight turn-up. I don't know what this is. These cars are now on test and we will know more about it as the test progresses, but this is characteristic and we wanted to show you and have you see and we would predict this would be the effect of reduction of lead content on the current population of cars that could use that fuel. That is all the slides.

I am sorry we have to go to a different technique for showing information, but this is now a view graph curve we brought along with us.

What we wanted you to see here is the effects of lead on the octane rating of gasoline and this happens to be the motor number and this is the research number and this happens to be the lead content in grams per gallon, so on the motor side, if you come down here to half a gram, you see you move up rather rapidly with a small amount of lead in the fuel. Here is regular and here is premium.

Then what we looked at when we were talking about the 91–97 we were talking about research numbers and a half a gram moves us up, we feel, somewhere in the area of about 2½ numbers, something of that type, and I want you to keep that in mind that this curve has a tendency to bend over as you go up higher in lead, so you still gain even though you go up to 4 grams or about 4 milliliters per gallon.

Are there any questions? This is a quite important curve or result that I will be talking about here in just a little bit. Okay.

Now, as I indicated, our 1971 models are all designed to run on either leaded or unleaded 91 research number fuels, and we also said that to meet the 1972 California standards we would like to have 91 unleaded fuel available.

Now, in light of information we received yesterday, I believe General Motors could modify its position to some degree. We understand the problems that we didn't know about before a little better, and on that basis, we would like to make these following suggestions to the Technical Committee and the Board for their consideration.

This is for California only: Modify regular fuel from 94 research octane number leaded which is now approximately 3 grams or 3 milliliters per gallon to .5 milliliters lead per gallon at 91 research octane numbers.

Now, this would ease fuel molecular upgrading that was talked about yesterday to increase the octane level and I believe it still would make it possible, and this is where the pitch is, I believe. It would still make it possible for us to meet the 1972 and 1974 California emission standards.

Then two: By the 1975 model year provide unleaded—this is model year by the way—91 research octane numbers nationally.

Presently we know of no way to meet these more rigid California and HEW standards which I pointed out earlier with leaded fuel because of the more severe treatment of exhaust gas that we feel will be necessary by either the use of a catalytic converter or exhaust reactor. And further we believe lead will affect either the catalytic treatment or the exhaust recirculation device which we would use to reduce oxides of nitrogen emission.

Now, this proposal would give turnaround time for both the petroleum industry and would also give us some benefit in easing our concern about valve life deterioration without any lead in the fuel. However, it will require a more expensive and complicated oxides of nitrogen control from 1972 through 1974 model years.

And third: It would permit lead to be used in premium grade fuel up to 4 milliliters per gallon at about a 97 research octane number.

And four: It would provide means to eliminate the possibility of fuel with more than a half milliliters per gallon being used in the 1972, 1973 and 1974 model year new cars. This is to permit the emission control devices to function properly and to reduce the inherent lower emission level of lead fuel which is of lower lead content fuel, which then would be about 16½ per cent of the current lead in regular fuel.

So we feel overall then that the best solution, as we see it, to the current problem could be accomplished on this basis:

1. Two grades of fuel from 1972 through 1974 model year with the regular grade at 91 RON and .5 milliliters per gallon, and the premium grade 97 RON and up to 4 milliliters of lead per gallon.
2. Two grades of fuel for the 1975 model year and beyond. A regular grade of 91 research number RON with no lead, and the premium 97 research octane number with lead with a maximum of 4 milliliters, phasing out lead as improved refinery technology was developed or equipment was replaced or volume expanded.

We believe this solution should have very little impact on fuel cost and should hold down the investment in refining distribution facilities, and further, we think it will make a substantial contribution to the older cars that can use the .5 milliliter fuel as a regular grade. Thank you very much.

Dr. STARKMAN. Thank you, Mr. Cole. I will call on members of the Board and members of the Technical Advisory Committee. Dr. Cattaneo.

Dr. CATTANEO. We have heard frequently mentioned the problem of valves in the absence of lead. I am always surprised at that. After all, there are Diesel engines operating without lead and I think there is considerable technology available. I remember dealing with that problem 20 years ago which perhaps I could understand that the economics or something for the optimum solution may have to be determined, but as a technical problem, I have trouble believing there is really something we don't know enough and have to do basic research on.

Mr. COLE. There is no basic research involved. We know how to handle this problem. We are currently handling it on truck engines. We handle it in dry gas engines currently. There is no problem of handling it. The question I think most of us have would be the effect of valve life on the current population of the cars that do not have the changes that might be needed to make the newer engines run on the unleaded fuel, but we have done an extensive research job in this area, and we have investigated the results of operation and on the east coast where 20 per cent of the American Oil Corporation's fuel is an unleaded premium fuel, and we have no indication of any valve problem in that area whatsoever.

Now, the problem that they tell us is that occasionally the person that thinks he is using the unleaded fuel all the time and occasionally get a tank of leaded fuel and that heals things up. We are not sure about that.

As I stated, we don't feel that is a hangup at all in getting this job done.

Dr. STARKMAN. Mr. Chass.

Mr. CHASS. Mr. Cole, yesterday I heard some statements that you will be lowering the compression ratio from this point on until you reach a certain point in time at which the compression ratio would tend to increase. Would you support legislation to limit the compression ratio to 8½ at this time?

Mr. COLE. No. Compression ratio is a very flexible figure. I can have a 10 to 1 or 12 to 1 compression ratio that can be run on 85 fuel if necessary. It depends upon the engine configuration. You can reject a part of the charge through valve timing so that you don't run the high pressures in the cylinders, so I would say that you tell us as far as the Board is concerned what performance standard you want and don't tell us how to design our engines.

[Applause.]

Dr. STARKMAN. Mr. DeHaven.

Mr. DEHAVEN. Could I carry that line of argument a little further? As I understand it, General Motors is proposing that there be laws now that stipulate what will be in fuels in contrast to the past philosophy of this state, at least, and that has stipulated what shall come out of the automobile through the exhaust and where else it is, and I am a little unclear as to exactly your argument as to why there has to be a law on this particular subject on fuels in contrast to having stipulations of what should come out of the automobile which allows lots of solutions to occur possibly that this particular legal solution might not allow to occur. Do I make myself clear?

Mr. COLE. I think so. We haven't suggested any laws at all or any regulation in this area. This is something for the Board to consider and what we have said is what our needs are, how they are arrived at. This is the question, and if it was clearly stated the fuel and type of fuel that was going to be made available to us and it was clearly stated the standard to which we should operate and the time frame and we had the ensuing time to accomplish these objectives, I think we need regulations with regard to the standards so that everybody understands exactly what you mean as far as the emissions are concerned and the procedures, and once we have them, it is up to us as individual manufacturers to go about our own way in getting the job done.

So I would like to say we are not asking for regulations in that area other than what you want in the way of performance, and we are not asking for regulation of gasoline.

Dr. STARKMAN. Mr. Feldstein.

Mr. FELDSTEIN. Could you estimate what percentage of pre-1972 cars could operate on half gram lead, and would anything have to be done to the cars?

Mr. COLE. As you recognize, anybody that is familiar with the characteristics of our engines and the way they are maintained and how they are operated, there is quite a range of octane requirement for a given engine and a given car, but we feel by an ignition adjustment that all cars that are now operating on regular grade of fuel, that is designed for regular fuel, could operate on the 91 fuel unleaded or half a milliliter of lead, and I can support that a little bit further by some of the information we said yesterday.

If lead is taken out entirely, we pick up from 1 to 2 octane numbers as the mileage is accumulated because of the lower deposits, so in effect the 91 out of 20,000 miles is equivalent to maybe a 92 or 93.

Dr. STARKMAN. Mr. Chass.

Mr. CHASS. Mr. Cole, I want to understand your position here. Are you advocating then there be no legislation against lead content of gasoline?

Mr. COLE. As far as we are concerned, we can't take that position on the legislation if we can get the proper fuel without legislation.

Now, if the Board feels, the Committee feels it is necessary to control the lead content, that is something for them to decide, but from our point of view we usually have made our needs known in this area and if it is necessary since our customers are the customers of gasoline and your organization set up the regulations and we are required to meet them, so we have to indicate in our service manual or operation manual what our cars need to meet those standards, and that is what we propose to do.

Mr. CHASS. May I change the subject for a moment. Yesterday we heard from both the DuPont Company and Ethyl regarding their reactor of their control systems. Has General Motors tested either one or both?

Mr. COLE. Both.

Mr. CHASS. If so, what have you found in this case?

Mr. COLE. We haven't written off the reactor at all. As far as we are concerned yesterday we said that we were considering both the catalytic treatment as well as the after burner approach which is the exhaust manifold reactor, but we did say we have had some serious problems with excessive metal corrosion with lead in the fuel with a high temperature reactor.

Now it is possible, without any question, probably to overcome some of those problems, and those aren't the only problems I would like to say because those reactors must run from 15 to 1800 degrees of temperatures in the engine compartment environment. They are close to the master cylinder generating heat unless you insulate them completely. They are close to a lot of plastics. They also give off a lot of heat that affects our suspension insulators and you are not just talking about the cost of the reactor. You are talking about the total cost of making the reactor work in this particular environment, and so this is our concern, the high temperature characteristics of this reactor, and this reactor must come up in temperature rather rapidly in order to function and further the cylinder head to which the manifold is fastened is running cold and the reactor is running at a high degree and there is a tremendous amount of difference in thermal expansion.

I suspect we have run maybe 2,000 reactors in our system on all kinds of cars. We have a very large staff working in this area, and we have nothing against the reactor if it can be made to work. Don't forget we have got to make five million of these a year and have everyone work, and it isn't like making one work in the laboratory and taking it around and showing people how good it is. Every one of these has to work with all the variations that we have in our products from day to day, and they have got to meet standards on a 100 percent basis and this is our concern.

Dr. STARKMAN. Mr. Cole, my extrasensory perception tells me there is a question in the minds of a lot of people in the audience here and one you are eager to answer. Why did we go up to 10 compression ratio in Cadillacs when the customer doesn't know the difference at 8½?

[Applause.]

Mr. COLE. This is a very good question. You might say why are Diesel engines operating on an 18 to 1 compression ratio.

The fact of the matter is this, and if you are familiar, you can see it in any thermal dynamics book, the thermal efficiency curve has quite a knee in it and breaks over rapidly at about 8½ to 9 to 1, and as you go further up in ratio, you increase your pressure rise and other forces on the engines faster than you do economy or performance. On the other hand, we are seeking as much improvement in efficiency and performance as we could get.

Now, we have run engines at 12 to 1. We have run 14 to 1 and you get a lot of vibration and noise with very little improvement, so really, you are crowding it a little bit when you go to 10 to 1, and we feel, and I would like to make this statement, it is not our position to chase this compression ratio up again until the petroleum people have demonstrated that they can do this on an economical basis, and that is, supply the unleaded fuel on an economical basis and further that we can find a way to control emissions properly with higher ratios.

I would just like to make this point again, as I did yesterday, going from 10 to 1 you inherently drop the hydrocarbon emissions by 28 percent and oxides of nitrogen by 23 percent. so there is an improvement by dropping ratio as far as emissions, and emissions is a new ball game.

This is something we didn't have to worry about when we were going up on powered economy. Now, it is a different story.

Dr. STARKMAN. We have a question from Dr. Pitts.

Dr. PITTS. I was just checking through the notes I made on your proposal here. The solution when you said, Mr. Cole, say in the 1971 model you will still provide 97 RON with the lead max 4 milliliters, was that to be used on——

Mr. COLE. Past models only. It is a matter of phasing out the older cars that are now on the road that require the higher octane fuel.

Dr. PITTS. The same thing for '72 and '74?

Mr. COLE. That's right.

Dr. STARKMAN. Mr. Schmid.

Mr. SCHMID. I would like to ask Mr. Cole—the statement was made yesterday several times that any change in your octane rating and so forth would necessitate a tremendous cost by oil companies from the standpoint of distribution, tanks, service stations and so forth, that could run into millions of dollars. I gather from your presentation this morning that you feel by staying with just two grades of gasoline and reducing the octane in both that most of this would be eliminated, that very little extra cost would fall on the oil companies, at least in your transition period. Am I correct?

Mr. Cole. That is our opinion. We don't represent the refining industry, but I think some of the refiners that will come up can be asked that question, but it is our opinion and our analysis and why we suggested 91 octane fuel to begin with, and this was a very elaborate study. We felt there were sufficient molecules of good fuel available so that we could come up with around 90.6 is the figure that came out actually, so that you could have a base of 90.6 unleaded and you put the 7 octane numbers on with 3 milliliters of lead and you have got 97, and it is just as simple as that.

Dr. Starkman. Dr. Beard.

Dr. Beard. How do you propose to control particulates? What is the system?

Mr. Cole. First of all, let me say this: When Dr. DuBridge called me about the meeting with President Nixon and the Cabinet and the Air Qualities Board, we had never heard about particulate control before, and so I got busy and called our research people and said, "What do you know about particulates?" And they said, "Practically nothing," and this was an awful state of affairs, I would say under those circumstances, so we did get busy and dug as much literature as we could find on it and we have that data, if anybody is interested, of the exhaust content and the lead that actually is in the particulates. Now, it is very difficult to measure this, and I hope if you set up a standard, and as yet HEW don't know how they are going to measure it or what kind of a procedure because under some cycles of slow running you accumulate these particulates if they are not blown out, and then you make a fast acceleration and you have seen it on the streets yourself. Kind of a cloud comes out of the car on a fast acceleration and there is a lot of particulate. That is what you are looking at, so this is a very difficult thing for us and our research people are designing devices that have 100% filtration. In other words, on the smallest micron likely to come out of the exhaust, we are going to catch it and find out what it is, and we have that equipment available today.

Dr. Starkman. This is research, not application?

Mr. Cole. If you saw what it was, you wouldn't want it on your car.

Dr. Starkman. Some of the people sitting up here would like to know what that devise is so they can attach it to smokestacks.

Mr. Chass. One more question, Mr. Cole. In trying to sort out economics of this entire problem, there is one number that hasn't been mentioned. You said for some of your pre-1971 cars it would be possible to adjust the spark to use lower octane?

Mr. Cole. That is correct.

Mr. Chass. What would be your estimate of the cost per vehicle to do this?

Mr. Cole. It wouldn't cost anything if it was done during the tune-up because that is part of the tune-up, and if you had to do this at the gas station—most gas stations have facilities to do this and it is a very minor operation.

Mr. Chass. You won't venture an opinion as to cost?

Mr. Cole. Well, I would say you are talking about less than 20 minutes of labor to do the whole thing, so you just apply the hourly rate and you can get an idea of what it is. It won't be very expensive and it is part of the normal tune-up to adjust the spark.

Dr. Starkman. Thank you, Mr. Cole.

Mr. Cole. I would like to make just one or two more points that were confusing yesterday and I think, Dr. Pitts, that you wanted some clarification, and we are in a position to clarify the aldehyde issue. Bill, do you want to take that along with the Bureau of Mines 25 per cent thing? I think we are in a position to clarify both of those.

Dr. Starkman. Mr. Cole, I am going to call on Mr. Hurn who I think published the 25 percent difference.

Mr. Cole. I believe we have some information on that, too. Maybe we could introduce it at that time.

Dr. Agnew. What we are talking about here now is the question of aldehydes and the effect of lead removal on aldehydes. I think the real situation here is the experiment has not yet been run to find out what the action we are talking about here in this meeting would have on aldehydes. That experiment has not been run. There have been experiments run, a very few number of experiments, in which lead has been removed from gasoline and they have seen some increase in aldehydes. I think we can explain that situation, and it is not the situation we are describing here today.

There has been research work published, I think, by the Texaco people which indicated that a large amount of the aldehydes we do find in exhaust gas comes from pre-flame reaction which occurs in the end gas of the cylinder in the combustion chamber and in the quench zone at the time of combustion process in the engine. Now, if you run an experiment in which you have a leaded gasoline, you create a certain amount of these aldehydes in the end gas pre-flame reaction. If you then take the same engine, the same gasoline and remove the lead, you will tend to have more pre-flame reaction, but the experiment still has to be non-knocking in both cases so you don't have a condition which corresponds to what we are talking about today because what we are talking about today is removing lead from the gasoline and then lowering the compression ratio which reduces the stress on these gases and that would reduce the amount of aldehyde formation, so the situation we are talking about today is one in which the stress on the end gas is the same with leaded fuel or unleaded fuel. We would not expect the aldehydes to be increased in that situation.

Dr. STARKMAN. I think Dr. Haagen-Smit has a question.

Dr. HAAGEN-SMIT. I was wondering, Mr. Cole, in the past we have set standards rather lenient, as you know, so it became a kind of a goal to meet those intermediate standards. Now, we have the '74–'75 standards and 1980 standards. What I am wondering about is we are not losing some time and money by working for the 1975 standards. Actually, you should be working for the 1980 standards. You see my point?

Mr. COLE. Yes, I see your point, and we are running cars at that point that our measuring devices can't measure emission and maybe California has got more accurate equipment than we have, so if you can't measure emission, I think we can make the 1980 standards on the current cycle. So I have no fear of our technological competence to do the job for 1980 or 1975 providing we have the fuels that will permit us to do it. We have the technology and we have the capability from a manufacturing point of view, and I would like to add one thing, we are trying to develop into our advanced system self-monitoring devices. Now, normally an operator doesn't know when the emission system is not working satisfactorily, and you just do it through a tune-up. We hope to be able to indicate to that operator that emission control devices are not functioning up to the level they should be functioning, and I think this is part of the system we want to get into as far as further sophistication and this gets into the space age technology and some other things that are very advanced, and we would be happy to show all of this to the Board any time you would like to see it.

I would like to make one more point, Dr. Starkman, on this truck thing that was brought up just briefly. As you know, we have a sizeable truck production and we think the proposal we have made is completely compatible with the truck performance.

Dr. STARKMAN. I think we ought to let Mr. Cole off the hook now temporarily and call next on Mr. Norris, please.

Mr. NORRIS. I am Kenneth B. Norris, chairman of the board of Norris Enterprises, Los Angeles. I am speaking here in this meeting as a private citizen and I say just almost that we became just a little pregnant recently when we made a deal with Pacific Lighting to produce this device they have, but aside from that, we are not connected with this particular program at this time although

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agreement, and to replace our present processes with new processes, we would have an adjustment of, let's say, of X to come up to today's octane level with lead and to go beyond that point we have got to start thinking about completely new additional investments.

Now, there is no conflict in what I have said here, that is, with today's knowledge. If that were not the case, we just finished building this plant in Chicago, obviously if we knew how to do it, we would have come out with 100 unleaded premium and 94 unleaded regular. We don't know how to do it. That makes sense to the public. That is definitely going to cost 2 to 3 cents more a gallon looking down the road that may happen, some scientist in our company or Jersey or U.O. or somebody may work something out, let's hope maybe they do.

On the other hand, I heard the statement this morning from Mr. Cole that he seems to have no intention of going back to raising the compression ratio of cars, or let's put it another way, and to quote him correctly, they expect to keep making cars for a long time that have engines in them that require only 91 research octane number fuel. You might ask him if that is my correct understanding.

Dr. STARKMAN. Ask him right now.

Mr. COLE. Yes.

Mr. HARTLEY. His answer is yes, so we are going to redirect our reseach work not to try to improve the octane quality of the gasoline further.

* * * * * * *

Chrysler people themselves its an APRAC contract, and I just want to know, Charlie, do you have any results on that?

Mr. HEINEN. No, I don't. That is not a Chrysler program, an APRAC program, but I happen to be Vice-Chairman of APRAC and this is not a Chrysler APRAC deal. I don't have the data here and I don't care to talk about it without having that data.

Dr. PITTS. It is the impression I had there was no increase in polynucleolar aromatics, but they are preliminary and won't go any further than that.

Mr. HEINEN. That is the reason I don't want to talk about that today. They are preliminary, you are correct, not a major effect shown, but it is very preliminary.

Dr. PITTS. I agree this is a very important point in our minds. We will look forward with great interest to seeing more specific and detailed data on that point.

Dr. STARKMAN. Bill Agnew can comment on this.

Dr. AGNEW. I would like to say we have been working in General Motors on the effect of gasoline composition on polynucleolar aromatic emissions. One piece of data published in Science indicated we have found one to two PPM of benzo (a) pyrene in the gasoline itself and 36 per cent of that benzo (a) pyrene came through the exhaust so this was one source of polynucleolars in the exhaust gas. I have had additional work in which we changed composition of the

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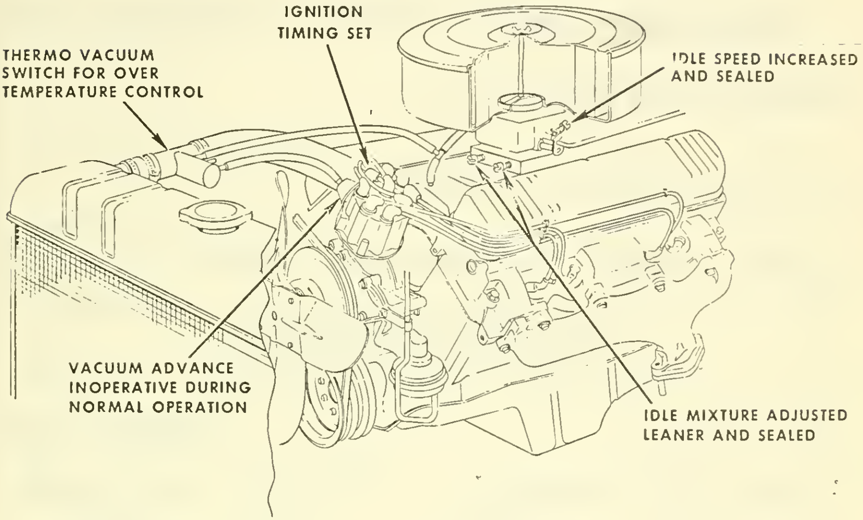
(The following material was supplied by General Motors.)

USED CAR EMISSION KIT DATA SUMMARY

GM EMISSION CONTROL SYSTEM FOR USED CARS


IGNITION TIMING SET
THERMO VACUUM SWITCH FOR OVER TEMPERATURE CONTROL
IDLE SPEED INCREASED AND SEALED
VACUUM ADVANCE INOPERATIVE DURING NORMAL OPERATION
IDLE MIXTURE ADJUSTED LEANER AND SEALED

MATERIAL SUPPLIED WITH KIT

1. INSTRUCTION SHEET
2. THERMO-VACUUM SWITCH WITH ASSOCIATED HOSES AND CLAMPS
3. SEALANT AND TAGS FOR IDLE SCREWS

KIT SPECIFICATIONS

1. IGNITION TIMING: MANUFACTURERS SPECIFICATIONS
2. DISTRIBUTOR VACUUM ADVANCE INOPERATIVE-THERMO VACUUM SWITCH FOR OVERHEATING PROTECTION
3. IDLE SPEED: 600 RPM - AUTOMATIC TRANSMISSION
   700 RPM - MANUAL TRANSMISSION
4. IDLE MIXTURE: 14:1 AIR/FUEL BY ANALYZER

INSTALLATION SEQUENCE

1. INSTALL THERMO-VACUUM SWITCH IN TOP RADIATOR HOSE
2. SET IGNITION TIMING
3. SET IDLE SPEED AND MIXTURE
4. APPLY SEALANT AND TAGS TO IDLE SCREWS

TEST PROGRAM SUMMARY

		COMPLETION DATE
• FEASIBILITY STUDY EMISSIONS (DETROIT)	10 CARS	DEC. 16, 1969
• COOLING AND COLD DRIVEABILITY (DETROIT)	10 CARS	JAN. 29, 1970
• ECONOMY AND WARM DRIVEABILITY (PHOENIX)	22 CARS	JAN. 27, 1970
• DEALER INSTALLATION EVALUATION (LOS ANGELES)	59 CARS	MAR. 5, 1970
TOTAL	101 CARS	

COMPOSITE EMISSION RESULTS

COLD START

	HC(ppm)	CO(%)	NOx(ppm)	% PASS
STANDARDS	350	2.0	800	90
100 CARS	322	2.2	656	86

EMISSION REDUCTIONS

(Hot Cycle Tests)

	AVERAGE EMISSIONS		
	HC(ppm)	CO(%)	NOx (ppm)
101 CARS AS RECEIVED	626	3.19	977
101 CARS WITH KIT	301	2.01	673
REDUCTION	52%	37%	31%

DISTRIBUTION OF TEST CARS

BY MAKE

GM		69
Buick	10	
Cadillac	7	
Chevrolet	29	
Oldsmobile	11	
Pontiac	12	
FORD		16
Ford	14	
Mercury	2	
CHRYSLER		11
Chrysler	2	
Dodge	3	
Plymouth	6	
AMC		4
Rambler	4	
STUDEBAKER	1	1
TOTAL		101

BY MODEL YEAR

1954	1
1955	1
1956	1
1957	6
1958	2
1959	7
1960	6
1961	9
1962	10
1963	17
1964	21
1965	19
1966	1
TOTAL	101

MILEAGE OF TEST CARS

ODOMETER RANGE	NUMBER
UNDER 40,000 MILES	9
40,000 TO 60,000 MILES	29
60,000 TO 80,000 MILES	40
80,000 TO 100,000 MILES	13
OVER 100,000 MILES	10
TOTAL	101

DRIVEABILITY EVALUATION
59 CALIFORNIA CARS

	NUMBER	%
CARS MADE WORSE BY KIT INSTALLATION 'Stretchy' Feel (10) Rough Idle (2)	12	20
CARS MADE BETTER BY KIT INSTALLATION	12	20
CARS UNCHANGED BY KIT INSTALLATION	35	60
	59	100

CHANGE IN CREEP SPEED

AVERAGE INCREASE 2.2 MPH

EFFECT OF KIT ON COOLING AND FUEL ECONOMY

COOLING

- COOLING PERFORMANCE IS ACCEPTABLE WITH THERMO VACUUM SWITCH

FUEL ECONOMY (22 CARS)

	BEFORE KIT	WITH KIT	CHANGE
CITY ECONOMY	12.6 MPG	12.4 MPG	0.2 MPG LOSS
HIGHWAY ECONOMY	14.4 MPG	14.1 MPG	0.3 MPG LOSS

REQUIREMENTS FOR USED CAR EXHAUST EMISSION CONTROL

- KIT
- INSTALLATION
- CONDITIONING OF SOME CARS
- MAINTENANCE

CONTINUING PROGRAM

- FOLLOW UP TESTS ON CUSTOMER CARS WITH MILES (CALIFORNIA INSTALLED KITS WERE LEFT ON CARS)

- INSTRUCT CLASS 'A' STATION MECHANICS ON THE INSTALLATION OF THE KIT

Senator SPONG. These hearings will be in recess until 1:30 when we will hear testimony from the Standard Oil Co. of Indiana. At that time, we will be joined by Chairman Randolph of the Public Works Committee.

(Brief recess.)

Senator RANDOLPH. Good afternoon, gentlemen.

We will continue the hearing and hear Mr. Robert C. Gunness.

Mr. Gunness, you have associates sitting with you. For the purposes of our record, I wish you would identify them and perhaps we may have an opportunity to hear them briefly. Certainly their statements will be included in the record, and you may proceed as you desire. Do identify the men who sat with you at this time.

STATEMENT OF ROBERT C. GUNNESS, PRESIDENT, STANDARD OIL CO. (INDIANA), ACCOMPANIED BY PHILIP C. WHITE, GENERAL MANAGER OF RESEARCH; AND RUSSELL C. MALLATT, COORDINATOR FOR AIR AND WATER CONSERVATION

Mr. GUNNESS. Thank you very much, Mr. Chairman.

Members of the committee, my name is Robert C. Gunness, and I am president of Standard Oil Co., Indiana.

I would like to introduce Mr. Philip C. White, and Mr. Russell C. Mallatt. Dr. White is our general manager of research. Mr. Mallatt is Standard's coordinator for air and water conservation.

On behalf of our company, I would like to express our appreciation for the opportunity to appear here today.

Our company recognizes that environmental pollution presents a serious threat to the well-being of our Nation, and we strongly support the desire of Congress to take steps to assure cleaner air and water.

We recognize that many of the blueprints for our national struggle against air pollution emanated from this committee. We also know that much of the legislation which the Congress enacted was made more effective and produced beneficial results largely because, in framing this legislation, you gentlemen were willing to take into account the technical and economic considerations brought before this committee by expert witnesses.

Today, we would like to discuss those areas of your inquiry in which our company has had direct experience. We hope the information we shall furnish will be of help to you in evaluating some of the provisions and implications of proposed legislation.

Specifically, we would like to comment on section 5 of S. 3466 which would authorize fuel composition standards and registration of fuels. In doing so, we would like to discuss recent developments with respect to lead in gasoline and to provide related background information. We would also like to comment on provisions of S. 3229 relating to Federal funding of so-called low-emission alternatives to the internal combustion engine.

Senator RANDOLPH. At that point, Mr. Gunness, a question. I have noted your background; although you are now the president of Standard Oil Co., of Indiana, you first began your work with this organization in research and development, is that correct?

Mr. GUNNESS. Yes, it is, sir.

Senator RANDOLPH. I think it is important to document for the record that you speak as someone who understands the problems of research by reason of having come through various levels of research responsibility with your organization. For that reason, we look upon your testimony as coming not only from the president of a company, but from a man with direct leadership in all phases of the company's scope of activities.

(A brief biography of Mr. Gunness follows:)

ROBERT C. GUNNESS, PRESIDENT, STANDARD OIL COMPANY (INDIANA)

Mr. Gunness joined the Research and Development staff of Standard Oil Company (Indiana) in 1938; became Assistant Director of Research in 1943; Associate Director of Research in 1945; and Manager of Research in 1947. In 1952 he was appointed Assistant General Manager of Manufacturing; was elected to Board of Directors in 1953; and was named Executive Vice President in 1956, with the assignment of directing and coordinating activities of the manufacturing, sales, and supply and transportation departments. He was assigned additional responsibilities in 1958, primarily in the field of coordinating of activities of some of the company's major subsidiaries. He was elected president in 1965.

Mr. Gunness was born in Fargo, North Dakota, in 1911; grew up in Amherst, Massachusetts, receiving his Bachelor of Science in Chemistry from the University of Massachusetts, and later earning a Doctorate of Science Degree in Chemical Engineering at Massachusetts Institute of Technology. He remained at MIT as an Assistant Professor of Chemical Engineering for two years.

Dr. Gunness is a specialist in distillation and heat transfer and is prominent in the development of new processes in petroleum refining.

In 1951 he came to Washington on leave from the company to become Vice Chairman of the Research and Development Board of the Department of Defense.

Mr. GUNNESS. Thank you very much for your comments, Mr. Chairman.

First, I would like to commend you, the chairman, and cosponsors of S. 3229 for those provisions which would extend authority to establish national vehicular emission standards to forms of transportation other than the internal combustion engine.

Marketing, as our company does, in 48 States, we believe that the establishment of emission standards by the Federal Government is the most practical way to regulate contributions to air pollution caused by the operation of motor vehicles. We believe that it would place an intolerable burden on both the petroleum and the automobile industries if such regulation were left to the individual States, with a predictable tangle of conflicting standards. Federal standards for control of emissions from other forms of transportation should prove equally beneficial.

The promulgation of technologically and economically feasible standards on a national basis, well in advance of their effective dates, permits industry to plan and prepare on a rational basis, assuring that the standards will be met. Competitive forces in the economy are brought into action, concentrating the efforts and ingenuity of research, engineering, and other personnel to develop the best solutions.

Indeed, the recent flurry of announcements regarding lower compression-ratio engines and the proposed reduction of lead in gasoline, which we will discuss in more detail later, is a prime example of competitive forces already at work preparing to meet anticipated Federal 1975 and 1980 emission standards.

In my comments on these developments, let me note that I am presenting the experience and judgments of myself and my own company, and that I cannot presume to speak for the petroleum industry at large. In many of the areas involved, substantial differences in viewpoint have been expressed. I would further remark that my comments are being made at a time when there is a great deal of uncertainty as to the specific needs of the automotive engine which will be coming out of Detroit this fall, and thereafter. Further changes in manufacturers' plans could conceivably render certain of my remarks obsolete.

Standard of Indiana has been conducting research on automotive emissions in special laboratory facilities for more than a decade. Since 1966, we have also engaged in, or have financially supported, extensive joint research with others in both the petroleum and automotive industries, and with the Federal Government, in seeking ways to eliminate automotive pollution. The studies we have carried out, or jointly supported, cover not only the impact on emissions of fuels, additives, lubricants, and engine design, but also control of evaporations by various devices for the carburetor, fuel tank, crankcase, and tail pipe.

Senator RANDOLPH. You don't call that exhaust?

Mr. GUNNESS. Exhaust; yes.

I think the record of collective achievement by the automotive manufacturers to date has been excellent. Through crankcase ventilation control, reduction of evaporation from the fuel system, use of secondary air in the exhaust, and engine adjustment and redesign, and 80-percent reduction in total hydrocarbon and carbon monoxide emissions has been achieved in newer cars.

Going beyond this point, technology has been developed for the further reduction of hydrocarbons, carbon monoxide, and nitrogen oxides from automobile exhaust. One system, based on temperature effects, involves carburetion and timing adjustments in conjunction with exhaust-gas recirculation and afterburners. It does a commendable job.

For still lower emissions we must turn to a more advanced approach. A catalytic system appears to be required in which one catalyst reduces nitrogen oxides to nitrogen and byproducts and another catalyst converts hydrocarbons and carbon monoxide to carbon dioxide and water. Both systems are limited in their capabilities, particularly as related to service life, when used with fuels containing lead. Afterburners are corroded by the halogen scavengers contained in the lead fluid, and controls of the exhaust gas recirculation system are fouled by lead deposits. All known exhaust catalysts are gradually deactivated by lead and the catalyst for reduction of nitrogen oxides is poisoned rapidly.

These adverse effects are unfortunate from the point of view of the gasoline manufacturer, and of the consumer, since use of lead is a relatively cheap way to get the higher octane fuels required by modern cars. Therefore, we have tried hard to overcome the adverse effects of lead so that it may be retained in gasoline.

We have directed much of our own recent research toward the development of effective lead traps and lead-resistant catalysts. Several types of lead traps were investigated, but we found none to be more than 50-percent effective. We tested more than 200 catalysts, particularly those useful in reducing emissions of nitrogen oxides, and found none that performed satisfactorily with leaded fuels. We did find a number of catalysts that work effectively for extended periods of time, but only with unleaded fuels.

That is not to say that future research may not be able to overcome the adverse effects of lead in gasoline. However, at this point in time we do not foresee how it can be accomplished and we have no promising leads.

On the basis of our present technology, we and many other knowledgeable people in both the automotive and the oil industries have reached the conclusion that ultimate reductions in automotive air pollution from the internal combustion engine will not be possible unless lead is eliminated from gasolines. This conclusion has been reached entirely aside from the question of lead in exhausts as a health hazard, this being still a controversial matter. Only when the more advanced emission control equipment is used with unleaded fuel can the ultimate reductions in emissions be achieved.

In the light of the foregoing, John E. Swearingen, chairman of the board of my company, has announced that to help reduce pollution by the automobile, Indiana Standard will make unleaded gasoline available in its marketing areas at such time as the automakers distribute cars requiring such fuel. Many of our stations will be equipped for such distribution by the end of this year and essentially all the remainder by the end of 1971.

I am sure the committee is aware that elimination of lead from gasoline poses major problems to both automotive and fuel manufacturers. Without lead, gasoline is normally so low in octane number that modifications in engine design are required to permit satisfactory operation.

Although fuel octane numbers can be partially restored by more intensive refining, this result can be accomplished only at the expense of a lower yield of product from crude, ranging between 5 and 10 percent, and at substantially increased capital and operating costs. In short, it costs more to make lead-free gasoline, and the cost rises with each increase in octane number.

According to recent announcements by auto manufacturers, it appears that automobiles with engines having compression ratios lowered to enable operation on a 91 octane unleaded fuel will begin to appear late in 1970. There is also the recent suggestion that engines be modified to operate a low lead-content fuel, say one-half cubic centimeter per gallon, rather than the present level of nearly 3 cubic centimeters per gallon. As we understand the manufacturers' plans, the projected 1971 model cars will not be equipped to do a much better job of pollution control than are current cars, even though operated on unleaded or low-lead fuel. Proposed 1971 model cars will also be able to operate on fully leaded gasolines, as at least one manufacturer has stated.

It is misleading to imply that the major benefits that the removal of lead from gasoline can bring to automotive pollution control will be available this fall, or perahps for several years. I think it most important that this matter be clearly understood. The ultimate benefits of lead removal can only be obtained when the most advanced emission control equipment is incorporated in all cars on the road and they operate only on unleaded gasoline.

Until such time as Detroit equips new, lower compression-ratio cars with advanced control devices, little improvement in air quality will result from having unleaded gasolines generally available.

Yet, my company, and others, presently plan to have low-octane, lead-free or low-lead gasoline available, to the extent practical, by the end of this year. This effort is necessary if we are to meet the anticipated demand for fuel designed to meet the needs of the 1971 car models as announced by one manufacturer. Early introduction of low compression-ratio engines will advance the date at which cars requiring high-octane, leaded premium gasolines will be displaced from our highways and to that extent will accelerate the time when major inroads can be made on the automotive pollution problem.

We have studied the proposed 1975 Federal emission standards and consider them attainable and in the public interest. We urge that, despite the fact that some distribution of unleaded fuels may occur this fall, and increasingly thereafter, no legislative or administrative action be taken which would restrict the use of lead in gasoline before the 1975 standards take effect. Such restriction would be premature—not only because few cars would be equipped to take advantage of it, but also because general distribution of unleaded fuels will take many months to achieve.

Contrary to some opinions expressed recently, we believe that in preparing to meet the 1975 standards, the petroleum industry faces a formidable job of financing and building additional refining capacity and in providing additional marketing and distribution facilities.

It is very important to our industry, and to our customers that there be an orderly transition from the present situation, in which all cars are designed to operate on high-octane, lead-containing fuels, to that point in time—perhaps 8 or 10 years hence—when all cars then on the road are designed to operate on lead-free fuels. We think this transition can be made without the necessity of legislative or administrative compulsion other than the imposition of emission standards. We urge that this viewpoint be accepted and that further restrictions be minimized, since they inevitably limit competitive and technical progress.

It has been suggested by one automotive manufacturer, and more recently by a representative of the Office of Science and Technology, that the transition can be eased for the petroleum industry by adjusting all cars now on the road to operate at lower octane numbers than presently required. This, in turn, would permit the petroleum industry to supply a leaded premium-grade fuel, of, say, 97 octane number, to meet the requirements of present premium-grade cars, and an unleaded fuel, of, say, 91 octane number, to meet the needs of both existing regular-grade cars and all new model cars. Such a program would obstensibly permit the petroleum industry to avoid a heavy investment in new refining facilities and at the same time serve the public needs with only two grades of fuel.

Although we agree that such a program, if it could be effectively carried out, would reduce the need for major new refining investments, we have serious doubts as to its practicality. Let us recognize that there are nearly 100 million cars and trucks on the road which would require adjustment to permit operation on the proposed lower octane fuels, and that the outcome would be impaired performance.

There have been suggestions from the automakers, and others, that relatively inexpensive adjustments can be made, which would reduce engine octane requirements to the levels just suggested. However, in the face of the limited service facilities capable of making the necessary adjustments, and owner resistance to engine modifications for reasons of cost and convenience, we are forced to conclude many cars will not be adjusted and that there will be a continuing demand for current quality fuels for some time to come.

We feel a clear responsibility to meet such a demand from our customers. In addition we feel an obligation to meet the needs of our customers who may desire unleaded or low-lead fuel for their new model cars.

Recognizing that there are several important marketers who are already distributing, or are preparing to distribute, three grades of fuel, it is our judgment that realistically we have to be prepared to meet the needs of unmodified existing cars while at the same time supplying a new unleaded or low-lead fuel for the new model cars. To do otherwise would be to forfeit a portion of our customers, whose needs would be satisfied by our competitors.

Further, we find it difficult to accept the views of others that it is either simple or practical to adjust existing cars to use 91 octane regular and 97 octane premium fuels.

Provision of an added grade of fuel poses an enormous distribution problem for most of the petroleum industry. Today only 20 percent of the service stations are so equipped that they could market two grades of leaded and one grade of unleaded fuel.

However, we understand added stations are now being equipped on a crash basis to permit such marketing. As I have already noted, we are embarking on such a course, also.

We estimate that to equip all stations to distribute a third grade of fuel would require 1 million additional gasoline pumps and 300,000 added gasoline storage tanks, as well as a massive installation effort. These requirements are several times in excess of current annual manufacturing capacity for such equipment.

For the petroleum industry, the costs of equipping to distribute generally an additional fuel is perhaps $2 billion; for our own company we estimate the cost at nearly $100 million. The magnitude of the task leads us to conclude that the transition to a three-grade marketing situation, in which unleaded fuel becomes broadly available, will require several years to accomplish, even though at selected locations unleaded fuel will become available this fall.

Turning now from the problem of distribution of fuels to their manufacture, I would note that at present, about 40 percent of automotive gasoline is refined to about 93 octane and with the addition of lead is boosted to 100 octane. This is premium gasoline. Such premium gasoline is now used by some 40 million vehicles in this country.

The remaining 60 percent of all available gasoline is refined to about 88 octane and boosted to 94 octane by the addition of lead antiknock compounds. This is regular grade gasoline and it is used by approximately 60 million automobiles and trucks.

Clearly, the production of a 91-octane unleaded gasoline to meet the needs of the proposed new model cars will require more than simply eliminating lead, since such a procedure would produce a gasoline of only 88 octone. New catalytic reforming and other refining facilities will be needed to achieve the required octane improvement, with the amount of facilities required being dependent on each refining situation, and on the growth in demand for the new fuel.

The magnitude of new facilities required for distribution and refining necessitates substantial leadtime, and presents a compelling argument against legislative or administrative rulings which would necessitate elimination of lead without providing adequate time for an orderly transition.

I have indicated that we have perceived no entirely practical method of meeting the public need during the transition period other than by the supply of three grades of fuel, two leaded and one unleaded.

I would add that it is abundantly clear that the costs for manufacture and distribution of the added unleaded 91-octane fuel are significantly higher than for the presently available leaded 94-octane fuel; the unleaded product must carry a higher price.

No resolution of the pricing and multiple grade situation referred to above can be accomplished unilaterally without taking into account the competitive forces at work in a free marketplace. As I pointed out a moment ago, 20 percent or more of the existing service stations are capable of distributing three grades of gasoline.

This situation would appear to give them a distinct competitive advantage during the transition phase, and the pressures on other marketers to meet this challenge will be tremendous. I have already indicated how we will respond to this challenge.

This is but one aspect in the rapidly changing and frequently confusing situation we are now facing. Another is how the motorist is to be induced, or compelled, to choose a new unleaded fuel for his new model car when a lead-containing, higher-octane number and cheaper fuel is available.

One obvious method would be to establish a Federal gasoline tax differential between the leaded and unleaded product, providing an economic incentive for purchase of the latter. There may be other feasible methods. We urge that this matter receive careful attention.

There are, thus, a number of fundamental questions still to be resolved. I think it important to remember that the price of hasty, faulty, or erroneous decisions may be to defeat the purpose of the program and must ultimately be paid by the consumer.

As the committee knows, our subsidiary, American Oil Co., has for many years distributed in the East and South an unleaded fuel of premium quality, Amoco Super Premium Gasoline. We are in the unique and favorable position of having available high quality unleaded fuel for our customers in 25 States and the District of Columbia.

Manufacture and marketing of unleaded gasoline by American Oil Co. began as a regional operation along the east coast, using surplus benzol stocks acquired after World War I. As the compression ratios of engines increased and other refiners, including our own Midwest operations, turned to lead antiknocks to meet higher octane requirements, it was observed that Amoco gasoline with its benzol had a superior octane rating despite its lack of lead. It achieved an unusual market acceptance which has continued to this day.

People liked the engine cleanliness, reduced maintenance, and improved mileage of Amoco. Tests we have conducted on advantages to the customer in using our premium unleaded gasoline, in contrast to leaded gasoline, indicate that these equate to several cents a gallon, more than offseting the added penny a gallon we charge for the product because of its higher manufacturing cost.

The savings result from an approximate 3-percent increase in mileage and a reduction in the cost of maintenance observed over several years of car ownership.

As octanes have steadily increased in the years since the product was first introduced, we have built the necessary specialized refining facilities to keep it competitive in quality with leaded premium gasolines. In the process, we have pioneered in the use of catalytic reforming to produce the high-octane aromatic components needed to formulate this product without the use of lead. It should be recognized, however, that this product comprises less than 20 percent of our total gasoline volume, and is marketed in only a portion of our territory, as previously noted.

Several factors have favored the continued production of our unleaded premium gasoline. The crudes which supply our southern and eastern refineries are unusually well suited to catalytic reforming, and only the most favorable portions are used for Amoco manufacture. Further, much of the equipment used was built during periods of lower construction costs.

We are frequently asked why our company does not extend its marketing of unleaded Amoco, which commands an additional price, into the remainder of our marketing area. We have made many studies over the years on the economics both of marketing an unleaded regular as a companion to our unleaded premium, and of extending our unleaded premium marketing to other parts of our territory.

Our studies have led us to conclude that, in the absence of a compelling factor such as automotive emissions control, the wider distribution of unleaded fuels is economically unattractive. It is substantially more expensive to make both regular and premium grades of gasoline unleaded than to make just premium lead free. In the latter case one can select the most favorable crudes, using only the best fractions to produce Amoco, diverting the rest to regular grade.

In summary, I must emphasize that our experience in manufacturing and marketing unleaded gasoline is not representative of what would be necessary today for the industry, or for our company, to make all gasoline unleaded. Our experience does not indicate that it is a simple task for the industry to shift from a leaded to a nonleaded basis.

Gentlemen, I am aware that I have gone quite deeply into the matter of emissions research and standards, and the question of lead-free gasoline. One of my purposes in doing so was to provide adequate background, and a common understanding and perspective for discussing section 5 of S. 3466.

Section 5 would authorize HEW to establish and enforce standards for the composition, or the chemical or physical properties of any fuel or fuel additive, regardless of whether a relationship had been reasonably established between such properties and automotive emissions. We feel this requirement to be unwisely restrictive, and that need for such authority has not been demonstrated.

This section would extend registration requirements far beyond the provisions of the 1967 Air Quality Act.

Senator DOLE. Could I interrupt there for a brief question? I have to leave shortly. I have to go to Chicago.

Would your comments with reference to section 5, also apply to the amendment introduced by Senator Montoya, S. 3229? It states in part, "The Secretary shall, as soon as practicable, prescribe such standards with respect to standards of fuels of all types that is necessary to protect the public health and welfare and carry out the policy of this act."

I mention this amendment to S. 3229, as we might avoid later testimony. Have you had a chance to look at this amendment?

Mr. GUNNESS. I don't believe I have seen it; no, sir.

Senator DOLE. Maybe if it is satisfactory to the chairman you could comment on the amendment in a separate statement.

Mr. GUNNESS. I would be very pleased to do so and we will file such a statement with the committee.

(The following comment was later supplied by Mr. Gunness:)

Upon examining Senator Montoya's proposed amendment to S. 3229, I feel that my comments with respect to those provisions of section 5 of S. 3466 relating to fuel composition standards would apply equally to Senator Montoya's amendment.

Senator RANDOLPH. Senator Dole, I think Mr. Gunness and his associates would want to include in their verbal testimony, and that to be filed with the subcommittee, their feeling about the amendments of Senator Montoya of which you make mention.

Senator DOLE. Thank you, Mr. Chairman.

Mr. GUNNESS. Shall I proceed?

Senator RANDOLPH. Yes.

Mr. GUNNESS. These new provisions that are proposed relative to the composition of fuel would authorize HEW to withhold registration of fuels until the manufacturer furnished practically any information HEW deemed reasonable and necessary. We respectfully submit that these provisions are of questionable value and provide, at best, a circuitous route to the problem of air pollution control. In 1967, in framing the Air Quality Act, the Congress wisely rejected this as a fishing expedition approach. We believe that an extension of this section as presently proposed should again be rejected by Congress.

We question the value of the entire procedure of registering a fuel, as distinguished from fuel additives, since fuels are normally mixtures, containing hundreds of hydrocarbons whose exact proportions are unknown and fluctuate from day to day, all having a range of physical properties readily specifiable by the American National Standards Institute and other recognized scientific bodies.

We believe that the objective of this legislation can be better accomplished under existing law, by setting stringent emission control standards and leaving to the automotive and petroleum industries to determine how these standards are to be met.

We also believe that should it be deemed essential that fuel standards be prescribed, they be developed under a consensus method, with the participation by the primary parties affected—fuel manufacturers, automotive manufacturers, and Government.

Turning to sections of S–3229 dealing with proposed Federal funding for development of the so-called low-emission alternatives to the internal combustion engine, we respectfully submit that with a virtually pollution-free internal combustion engine in sight, there is no need for public expenditures in this area.

We believe that the development of any alternative source of motive power can and should be left to the initiative of those private companies willing to research and develop such vehicles, without imposing an added tax burden on the public. I learned this morning this view was not shared by all the automobile companies.

For a number of years, we and others have been evaluating the merits of new types of mobile power sources, including the steam and electric cars which disappeared from the scene years ago because they were inefficient. Our studies of these alternative power systems indicate clearly to us that in the present state of technology there is no adequate substitute for the internal combustion engine—in terms of performance, versatility, or economy.

And finally, I would like to speak to the subject of tax incentives. Congress has recognized that industry should receive some form of tax relief for pollution control expenditures. The latest expression of this principle is made in the Tax Reform Act of 1969.

While repealing the investment tax credit provisions, Congress provided an alternate form of incentive for pollution control expenditures by permitting taxpayers to amortize the cost of such facilities over a shorter period of time. These new provisions are contained in section 169 of the Internal Revenue Code.

The language of section 169 is broad enough to cover a facility designed to deal with pollution resulting from the manufacture of a product. However, it does not appear to be broad enough to provide an incentive for industry to make investments necessary to manufacture and market products that have been modified or altered to lessen pollution resulting from their use.

Certainly these types of expenditures are just as essential in the struggle for a cleaner air as those covered by section 169, and we believe that this section should be amended to include them. Accelerated depreciation does not reduce the Government's share of tax revenue—it simply postpones it.

We especially feel that such incentives should be given in connection with the huge expenditures that would otherwise not be made were it not necessary to make and market low octane unleaded gasoline.

Should the Congress decide that the entire cost of such facilities should not be amortized in this fashion, since in some degree they may serve multiple purposes. we would recommend that the Secretary of Health, Education, and Welfare be authorized to certify an appropriate percentage of such costs that would be eligible for rapid amortization, on a case-by-case basis.

Now I should like to summarize some of the points I have tried to make in my remarks.

All of us share a common concern over the quality of our environment, which we have treated too casually, for too long a time. In regard to our air, we now have in sight the means to bring under control one of the principal forms of its contamination—our vehicles—

through a combination of vehicle design and changes in the composition of its fuel.

With our ultimate goal in sight, our major remaining problem is how to minimize the social cost of introducing the new, nonpolluting, vehicles while still meeting the needs of the vastly larger numbers of cars and trucks now on the roads.

These are cars which, in practical terms, will be significant contributors to air pollution until they are retired—hopefully within the next 8 to 10 years. No matter how it is reckoned, the cost of cleaner air is going to be high and it is going to take time to bring it about.

My company will be ready to supply unleaded or low-lead gasoline as soon as cars properly equipped to eliminate air pollution with the help of this type of fuel are on the roads. We have begun to so equip ourselves and expect our task to be essentially complete by the end of 1971.

We believe the anticipated 1975 Federal emission standards, as we understand them, to be attainable and in the public interest, and we will do our part to see that they are met.

At the same time, we urge that no legislative or administrative action be taken which would restrict the use of lead in gasoline before these standards make the removal of lead essential. The only effect of such action would be to saddle a needless early cost on the motoring public without any compensating gain in the form of cleaner air.

Nor do we believe that the authorization of fuel composition standards and registration of fuels will advance the common cause. Rather, we believe restrictions should be avoided, to encourage unfettered competition and technologic progress.

Our company has been making and marketing gasoline since the introduction of the internal combustion engine, and we know a good deal about it. As I have stated, gasoline is a complex mixture of hundreds of hydrocarbons, whose exact composition is still unknown, but whose physical properties are held within a narrow range by procedures specified by recognized scientific bodies.

Needless restrictions on the composition or the properties of fuels and additives promise little more than impeding progress toward the objective of cleaner air.

Finally, we think that some form of tax incentives should be provided to help to offset the huge expenditures involved in manufacturing and distributing a new grade of unleaded motor fuel. The purpose of such expenditures is to reduce pollution of the atmosphere, and the contribution to the public interest is equal to that of any other form of pollution control for which incentives are already provided.

This completes my statement. I thank you for the opportunity to appear.

I will answer any questions that I am able to.

Senator RANDOLPH. Thank you, Mr. Gunness.

Mr. Gunness, let us refer to your informative statement. You say:

> We now have in sight the means to bring under control one of the principal forms of its contamination—

Meaning the air—

> * * * our vehicles * * * through a combination of vehicle design and changes in the composition of its fuel.

Now, there have been from time to time informal conferences of which you are aware. There has been mentioned in hearings during recent days the problem that your company and others might face with an automobile manufacturing company because of certain questions that arise from antitrust violations or alleged violations. Do you feel that we can meet those antitrust objections in an area of this kind or do you think legislation is the answer?

There would not be a coming together to set prices, but a coming together to try to work out these problems. I wish you would discuss this matter.

Mr. GUNNESS. I can hardly appear here as a legal expert on antitrust law. I can say this, that our own company has cooperated in research work with automotive manufacturers and have shared information. This, however, does not have as its objective or intended purpose in any sense of the word reaching an agreement as to how each company is to perform its basic function, to supply the automobile.

My own view would be that it would be constructive to have a series of conferences at which it is possible for both automobile people and fuel people to share information that they have respectively acquired in a technical atmosphere.

I would judge that as long as this does not involve agreement on a single course of action which all parties pledge themselves to there will not be antitrust implications associated with that. This is my understanding of the situation.

I would further comment that I don't think that it should be the objective of the Government to bring together automotive and fuel people and to ask them to jointly agree on a single course of action that is to be followed as far as the future of the relationships between fuel and the automobile. As my remarks indicate, we advocate a minimum of restrictions with the Government concerning itself with the establishment of emission standards for the vehicles, allowing our two industries to work together in providing fuel on the one hand and automobiles on the other that do in fact meet those standards.

Senator RANDOLPH. Mr. Gunness, I have requested Mr. Meyer, the counsel of the Public Works Committee, to look into this problem because we see difficulty in it. We see, also, perhaps, an obligation and a challenge to have so-called partnership understanding only in the sense of working together in an effort to be affirmative and constructive in the public interest. It might be that we could bring this about in a constructive manner through change in the law.

I wonder, Mr. Meyer, if you would make such comment as you might think would be helpful for the record on what you have determined as of this date?

Mr. MEYER. Our initial explanations have been very tentative. We do have plans to set up an appointment with the Justice Department and to discuss the matter with them.

There are examples under current statue involving other areas where limited kinds of agreements or joint meetings are permitted under the protection from violation of the anti-trust laws. I think we want to explore this in some detail with the Department of Justice officials so that all of the possible problems can be avoided while those that you have set forth can be achieved.

Mr. Gunness. I think that would be constructive activity on the part of the committee.

Senator Randolph. We will continue, Mr. Gunness. We want the record to show, so that you and others testifying from various industries and businesses and Government officials will know, that we are researching now the problems proposed in this matter.

Mr. Gunness, in your statement you were speaking of some form of tax incentives being provided to aid in lessening the heavy financial impact of the manufacturing and distribution of unleaded motor fuel. Here, again, we are in an area which is somewhat gray, from the standpoint of an incentive under our tax structure. Perhaps we might have some sort of public-private effort, somewhat like Comsat. What would you think of that?

Mr. Gunness. I think the expenditures that I have reference to will be integrated into the manufacturing and distribution systems of the individual private companies. I think, myself, that to have some sort of public-private investment in that area would prove to be a complicated situation.

Senator Randolph. Yes, I want you to discuss this with us because it is one point being proposed.

Mr. Gunness. We have suggested that tax incentives be used to encourage manufacturers to install the new catalytic refining equipment that will be required to make these improved fuels. I would not that in my testimony I have taken cognizance of the fact that frequently when we build a new refining unit it may serve more than one purpose. For example, on the one hand, it may permit us to develop lead-free fuel, but it may permit us to make more gasoline than we had been making or to replace an obsolete unit.

In such circumstances, one might argue that only a fraction of the facility is for the purpose of removing lead and that other portions of the investment are for other corporate purposes. To the extent that were true, it would seem to me reasonable to authorize accelerated amortization on only a fraction of the inventment involved.

Senator Randolph. Now, you talk about the magnitude of new facilities on page 10 that are going to be required for distribution and for refining. You say that we are going to need leadtime, and you are talking about elimination of lead. Then it was important to us "without providing adequate time for an orderly transition."

Would this run into the billions of dollars or the hundreds of millions or what? What figure?

Mr. Gunness. Well, our estimate of the amount of money required by the petroleum industry to permit the distribution of three grades of fuel, which we think is necessary to meet the customer's requirements, is of the order of magnitude of $2 billion. The investments that will be required for refining facilities will occur over a period of time as on the one hand the volume of unleaded fuel produced increases, with the new cars coming along each model year and, in addition, as a result of what we anticipate will be increasing octane requirements of newer model automobiles, as has been suggested by the automotive industry. We will be back into the so-called octane race again as we were 10 years ago.

Our estimate of what it would cost the industry to come up to what we consider to be reasonable octane limits of unleaded fuels, both regular and premium, is of the order of magnitude of $3 billion. So that we have then $3 billion for refining, $2 billion for distribution, and then the customer is put to the expense of fitting out his automobile with all the control devices that must be added to it in order to avail himself of the benefits of a lead-free fuel.

Here the expense is larger. Say, to take 100 million cars at $100 a car, that would be $10 billion; $200 a car would be $20 billion. You do arrive at the numbers that were reached in the hearings of $18 billion, or more, depending on what it really costs the customer to add all the additional equipment on the automobile to have sufficient emission control.

Senator RANDOLPH. Mr. Gunness, 100 million motor vehicles of varying sizes and use are on our highways. It is estimated that there will be another 50 million in the next 10 years. Is this the correct figure?

Mr. GUNNESS. I don't find that unreasonable. I don't know what compounded rate of growth that would be.

That might be a little bit high.

Senator RANDOLPH. Secretary Volpe discussed this in answer to a question when he was a witness at our hearing?

Mr. GUNNESS. Dr. White?

Mr. WHITE. At the recent rate of growth, considering the number of motor vehicles for 10 years, you will see a number like 50 million additional cars in another 10 years. So the only thing that would inhibit that——

Senator RANDOLPH. Please repeat that.

Mr. WHITE. Three or four percent growth in the number of vehicles has been a recent trend. Projecting that for another 10 years, compounding it, will bring you up to the 40 or 50 percent increase in the total number.

Senator RANDOLPH. I thought when I suggested the 150 million to Secretary Volpe that he agreed it would be in that neighborhood.

Mr. GUNNESS. We consider that a reasonable estimate.

Senator RANDOLPH. A reasonable estimate.

Perhaps the growth rate might level off somewhat after that, but we are thinking in terms of billions of dollars and we are thinking in terms of compounding the problem because of the number of vehicles that are going to be operated.

Mr. Gunness, perhaps you have noted with pleasure or displeasure Secretary Finch's announcement on yesterday, I believe it was, in which he encourages the marketing of a lead free regular grade gasoline by July 1, 1974. This is the first national effort that I have noted toward a definite date for unleaded fuels.

Currently, the regular grade gasolines purportedly contains up to 2 grams per gallon. Is that right?

I am wondering if you have an estimate of how this action, if taken, as of that date, might affect the economy of producing both regular grade gasoline and higher octane gasolines. We must remember that the Air Quality Act provided for the registration of fuel additives. Proposed regulations were published, as you will recall, in the Federal Register last year. I don't believe the final regulations have been published. So we have very little data on the current types and funding of fuel additives, particularly lead.

Would you make some comment?

Mr. GUNNESS. I would be pleased to attempt to answer.

There are two dates in the press release which Mr. Finch put out. One was the date of July 1, 1974, to be established as the time when regular grade gasoline would be required to be unleaded.

I have already indicated in my remarks that I considered the proposed date of January 1, 1975, for new Federal standards to be a reasonable one that could be achieved.

Senator RANDOLPH. Then you are speaking of 1 year beyond the date.

Mr. GUNNESS. This is only ½ year. The difference between January 1, 1975, and July 1, 1974, is only 6 months. I would say there is an approximate agreement there. So I do not take great issue.

On the other hand, the Secretary also suggests that low-lead gasoline be available July 1, 1971. I would assume that low-lead gasoline corresponds to ½ cc. per gallon, as has been frequently referred to by General Motors and also by Ford. It would not be possible, in our opinion, for the industry to make a low-lead 94 octane gasoline available by July 1, 1971. The reason why this gasoline must be 94 octane number (not 91 octane) is so it can meet the requirements of the present-day cars that are currently operating on the highway. Thus I do not believe that the proposed low-lead regulation is a feasible one for the industry to meet from a refining standpoint.

Senator RANDOLPH. You can help the subcommittee, I am sure, by getting a statement on the fuel additives that presently are in use.

Mr. GUNNESS. We would be glad to submit that if that would be of help to you.

Senator RANDOLPH. I think it might be of help to us.

Mr. Grundy and I have talked about this. If you could supply it, not now, of course, but later.

(The information requested follows:)

STANDARD OIL CO. OF (INDIANA), CHICAGO, ILL.

NATURE AND PURPOSES OF GASOLINE ADDITIVES

Gasoline additives have been used for many years to improve certain properties and to minimize problems which can cause unsatisfactory vehicle operations. The attached table lists the major gasoline additives, other than antiknock agents, used by the petroleum industry. Brief discussions of these additives follow.

Surface ignition suppressors and spark plug life improvers

During the 1950's there was a rapid increase in the compression ratio of passenger cars and problems with surface ignition began to occur. Surface ignition takes place when the mixture in the combustion chamber is ignited by means other than the spark plugs. This undesirable ignition is generally caused by carbon-lead particles which are still burning from earlier cycle. The addition of small amounts of phosphorus-containing compounds to the gasolines will substantially reduce surface ignition by substantially increasing the ignition temperature of carbon-lead particles.

Phosphorus-containing compounds also increase spark-plug life. The presence of phosphorus reduces the electrical conductivity of deposits which collect on the plugs. Hence, shorting of the plugs is reduced and plug life is increased.

The amount of phosphorus used varies with lead content and is typically present in concentrations of 4–6 pounds of phosphorus per 1000 barrels of gasoline. This can lead to no more than 0.02 gram of phosphorus pentoxide, the major combustion product of phosphorus, per miles of vehicle operation.

Antioxidants

Antioxidants are added to gasolines to suppress oxidation which may occur during storage. When oxidation occurs, gum which can cause intake-valve sticking and peroxides which can cause engine knock are formed. Because of modern refinery practices, gasoline is generally more stable than it was in the '40s and earlier. Hence over recent years antioxidant usage has decreased. Alkylated phenols and aromatic amines are used in extremely low concentrations (1–3 pounds per 1000 barrels). Because they are completely organic (no metals), they are consumed during the combustion process to form water and carbon dioxide and would have no effect on air pollution by exhaust. The very small amount of nitrogen added to the fuel when aromatic amines are used could have no substantial effect on the emission of oxides of nitrogen in the exhaust.

Fuel line freezing inhibitors

Gas-line freeze-up can occur during extremely cold weather (0° F. or below) and is caused by freezing of water in low points in the fuel line between the fuel tank and the carburetor. When this occurs, the vehicle will not run and it is necessary to tow it into a warm location, such as a heated garage, to melt the ice plug in the fuel line. Fortunately, gas-line freeze has never been a common occurrence; when it does occur, however, it is extremely annoying to the customer. Methanol in amounts of about 0.05% are used in some gasolines to prevent gas-line freeze. Methanol contains only carbon, hydrogen, and oxygen and upon combustion should not lead to increased pollutants in automotive exhaust.

Dyes

Dyes have been used in gasolines ever since lead-antiknock usage began. All gasolines containing lead are required to be colored. The dyes are used in extremely small amounts, are completely organic, and should not lead to increase pollution.

Rust inhibitors

Rust inhibitors added to gasoline to minimize rusting of the distribution system system. These additives, used in concentrations of 5–10 pounds per 1000 barrels, are surface active-type organic compounds which contain no metals. Because they are used in low concentrations and are consumed during combustion, they do not cause increased pollution.

Carburetor detergents

Carburetor deposits build up when air breathed into the engine is dirty. The problem is particularly severe in city traffic when exhaust from other vehicles is breathed into the engine. Deposits collect in the throttle-plate area of the carburetor and restrict air flow at idle. Rough idle or idle stalls result. In addition, because air-fuel ratio is upset, substantial increases in unburned-hydrocarbon and carbon-monoxide content of the exhaust occur. Carburetor detergents are used to minimize the formation of these harmful deposits. They are surface active-type organic compounds and are used in concentrations of 5–10 pounds per 1000 barrels. Because they function by keeping the carburetor clean, they are helpful in preventing increased pollution in older cars.

Carburetor deicers

Carburetor icing occurs during periods when atmospheric humidity is high and the temperature is between 30°F and 50°F. When the carburetor is cold at startup, evaporation of the fuel causes a drop in temperature of the water-saturated air. This causes ice formation in the throttle-plate area of the carburetor, air flow is restricted, and the engine stalls at idle. The engine can be restarted without difficulty. However, carburetor icing can be a nuisance because, during adverse weather conditions, as many as a half-dozetn stalls may occur at stop lights or stop signs before the throttle-plate area becomes sufficiently warm to prevent ice formation. Carburetor-icing stalls are minimized by the use of 5–10 pounds per 1000 barrels of a surface active-type organic additive. Usually carburetor icing is controlled by the same additive which keeps the carburetor clean. In many gasolines, the same additive serves as a carburetor detergent, a carburetor deicer, and a rust inhibitor. Such additives are referred to in the petroleum industry as multifunctional additives.

Top cylinder oil

A few gasolines marketed in this country contain a small amount (0.1–0.2%) of a hydrocarbon lubricating oil. This is added to minimize deposit buildup on intake valves and to aid in the lubrication of the top-ring area of the engine. We have no informotion on the effect of the use of such an additive on emissions.

Boron and nickel

One major marketer uses an additive which contains boron and another uses an additive containing nickel. We do not have any information concerning the effects of these additives on air pollution. However, because of the extremely low concentrations of metals (boron and nickel) in these gasolines, we would expect their effect on air pollution to be minimal. However, extremely small amounts of boron and nickel, in the form of inorganic salts, could no doubt be detected in the exhaust of cars burning these fuels.

GASOLINE ADDITIVES

Additive	Function	Used by
CDP (phosphorus)	Suppresses surface ignition improves spark plug life.	Most majors.
Antioxidant	Improves storage stability	Probably everybody.
Deicer M (methanol)	Prevents gasline freeze	American.
Dye	Produces desired color	All.
Rust inhibitor	Inhibits rusting in distribution system	Probably all.
Carburetor detergent	Keep carburetor clean	Most majors.
Carburetor deicer	Minimizes carburetor icing	Do.
Top cylinder oil	Minimizes deposits on intake valves	Few companies.
Boron	Acts like phosphorus (CDP)	1 company.
Nickel	Claimed to keep combustion chamber clean	Do.

Mr. GUNNESS. Secretary Finch's announcement stated that he is sending a questionnaire to all oil companies, requesting information. We will be supplying that and if the committee would like it we will send you a copy of our reply.

Senator RANDOLPH. It might be necessary to employ an additive to remove lead from gasoline. I am not sure about this. I wish we had some comment on it.

Mr. GUNNESS. Mr. Mallatt will comment on that.

Mr. MALLETT. Comprehensive information on the types of additives and the amounts of additives that are used in gasoline have been made available to HEW by the American Petroleum Institute. I would suggest that that information be furnished to this committee.

Senator RANDOLPH. Yes. We will do that.

There is, I imagine, medical and scientific evidence to indicate that these additives are less toxic than lead under certain conditions. Is that right?

Mr. MALLETT. I am sure this is so. However, the information furnished had only to do with the type, not amount.

Senator RANDOLPH. Would you then say that perhaps the Secretary's action to date is commendable?

What is your feeling about what he has done?

Mr. GUNNESS. My own reaction, as covered by my testimony, is that the Government should stick to HEW emission standards and that is as far as they ought to go.

I do not, myself, favor the Government taking a position on the specific lead content at a particular date as proposed by the Secretary.

I think the result will be achieved with less restriction if we stick to the emission standards for 1975 that have been proposed.

Senator RANDOLPH. Do you think he might be instituting some sort of program without knowledge of what is happening?

Mr. GUNNESS. I think you can say this, that he has asked for a great deal of information from the various oil companies which will be supplied to him. He merely suggested one possible solution and I don't think he considers his suggestion as a firm recommendation, pending receipt of the requested information.

Senator RANDOLPH. Insofar as possible I hope we can move in a voluntary way.

I am asking you, Mr. Gunness, and your associates, if the public would be best served or better served by the development of alternate combustion systems. And I would like for you to discuss whether this would mean less loss of fuel resources, less cost in redesigning your refineries, less cost to the public in its annual fuel bills and less cost in development of so-called catalytic mufflers. Would you make a comment?

(Mr. Gunness subsequently supplied the following:)

In reviewing the transcript, Mr. Gunness recognized that he had misunderstood the chairman's question. From what we know of alternate combustion systems, and this would include the turbine engine as well as the steam engine, the electric car, and the so-called hybrid, we know of no system which can come close to providing as economical transportation as the conventional internal combustion reciprocating engine. Both the equipment costs and the fuel consumption for such alternate systems as we know them today and as they seem susceptible to improvement will be higher. Fuel consumptions might well exceed present levels by 10–20 percent, and engine costs by 50–100 percent. There seems little likelihood that pollution control devices, even in their more advanced forms, will carry a price tag this high.

Mr. GUNNESS. I think it is obvious that there is a heavy economic burden that is going to be put on the motoring public as we move to a pollution-less situation. During the early phases when octane numbers are reduced and compression ratios for the engine are cut back, as proposed, there will be a higher fuel consumption for miles traveled because the engines are less efficient. Presumably, over a period of time there will be a tendency for the motor manufacturers to raise the compression ratios of their cars as they seek a more efficient engine. There will then be a necessity for corresponding changes of the fuels we produce. It will cost more money and this will have to be recovered by higher gasoline prices.

However, on balance, I think it can be shown that with the higher compression engine you end up with a smaller overall travel bill for the customer than is the case with the higher performance engines.

Over and beyond that, the equipping of the individual car with extra equipment that is apparently needed is obviously going to represent an economic bill that he will have to pick up.

Senator RANDOLPH. Mr. Gunness, we thank you for your statement today and for your participation and that of your associates in colloquy. We want you to know that our record is not closed summarily, that there may be questions we would want to ask and have you answer in connection with your testimony. You may think there is something you would want to add on the basis of our exploring these problems. So we want you to feel that they could come from you as well as from us.

Mr. Gunness. Thank you very much for your courtesy. We look forward to hearing through you or through Senator Dole for the questions that he has.

Senator Randolph. Mr. Gammelgard. Your statement from the American Petroleum Institute is before us. I am going to have it made a part of the record. You might wish to comment on these three bills.

STATEMENT OF PETER N. GAMMELGARD, SENIOR VICE PRESIDENT FOR PUBLIC AND ENVIRONMENTAL AFFAIRS, AMERICAN PETROLEUM INSTITUTE

Mr. Gammelgard. I will make this brief and it might be a little disconnected.

First let me state our support for most of the provisions of S. 3546, The National Air Quality Standards Act of 1970. The requirement that the States adopt and enforce air quality standards for all areas not included in federally designated air quality control regions is a logical extension of the Clean Air Act, as amended in 1967.

There are a few things, however, where we would like to suggest changes in that bill. First, we believe that the penalties proposed in this bill for violations of air quality standards are unduly harsh and perhaps it might copy from some of the principles of the Water Quality Act insofar as penalties are concerned.

Secondly, we do think that the provisions dealing with class action suits should be dropped out of the bill. We can see no special reason why actions involving the alleged air pollution damage should originate in Federal district courts.

Third, with this particular filed the proposal requiring "the latest available pollution control techniques" to be applied on all new stationary sources appears to us to be inconsistent with the Air Quality Act of 1967.

I would like to turn now to S. 3229.

We think sections 202 through 209 are reasonable extensions of the Federal authority and we support them.

With respect to additive registration, the language of proposed section 210 of S. 2239 is identical to that adopted in 1967, and we urge that this language be retained.

Regarding section 212(a) on solvents, we endorse the position taken in section 212(a) by Mr. Willard Bixby when he testified here for the Manufacturing Chemists Association last Friday.

We believe that the proposed new section 201 of S. 3229 dealing with noise is timely.

Senator Randolph. I commend you for an enlightened attitude because I think that section is very, very important. I think that we must give more thought to that in connection with design of highways, as well as the cars that operate on them. We must also give increasing attention to noise and I think it is within the purview of the Federal Government to do this job and we must have the leadership at this level.

I appreciate your affirmative expression.

Mr. GAMMELGARD. Thank you, Mr. Chairman.

Turning now to S. 3466, driecting the Federal establishment of air quality standard and stationary-source emission standards we think would be a departure from the basic approach contained in the Air Quality Act of 1967.

I don't really believe there is any essential difference in the effect of these two bills, and I think we ought to stay with the existing law so that we get there faster without changing the ball game rules in midstream.

I say that because currently the air quality control regions are to set air quality standards for different pollutants. After they do this, the Federal Government must approve them. Obviously, the Federal Government is not going to approve any air quality standard that does not meet their idea of a minimum standard. In either case—the proposed new bill or under the old law—the local regions can set stricter requirements if they wish.

I think this change would only serve to create a sort of a chaotic condition.

As might be inferred from our support of section 210 of S. 3229, we do not favor granting the Federal Government authority to establish standards for fuel composition or additives, as is envisioned in S. 3466.

In the field of automotive air pollution, we believe that direct Government regulation of manufacturing methods or gasoline composition is not in the public interest and that the Federal Government's role should be to establish emission standards. If compliance with those standards is left to industry, it will encourage innovation and should result in lower costs to the public.

We believe HEW is to be complimented on having already announced its plans for 1973 motor vehicle emission standards and for having recently published in the Federal Register proposed standards for 1975. This shows an understanding of the need for sufficient leadtime to make major changes in production methods.

I have here, Senator, a few charts that might be timely to take a quick look at.

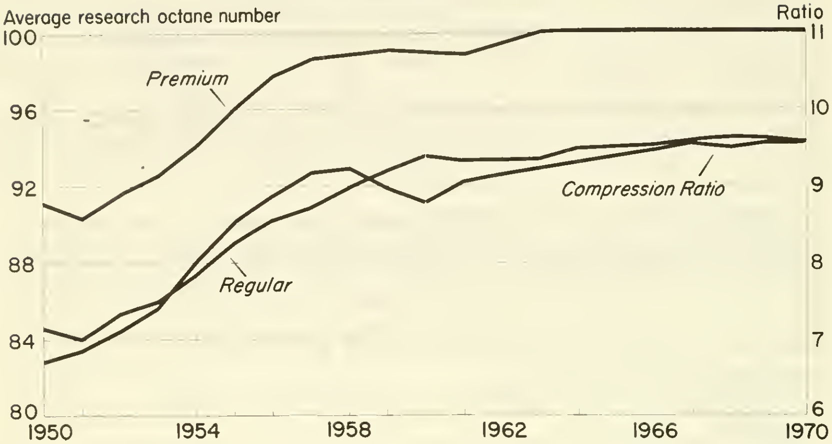
We have seen pollutants from cars referred to in parts per million, we have seen them expressed in percentages, and more recently in grams per vehicle mile. This has been quite confusing.

These charts purport to show what is happening in California and now what is happening nationwide in vehicle emissions, all expressed in grams per vehicle mile. I think it tells a pretty clear story. We will submit small copies of these charts for the record, if you wish.

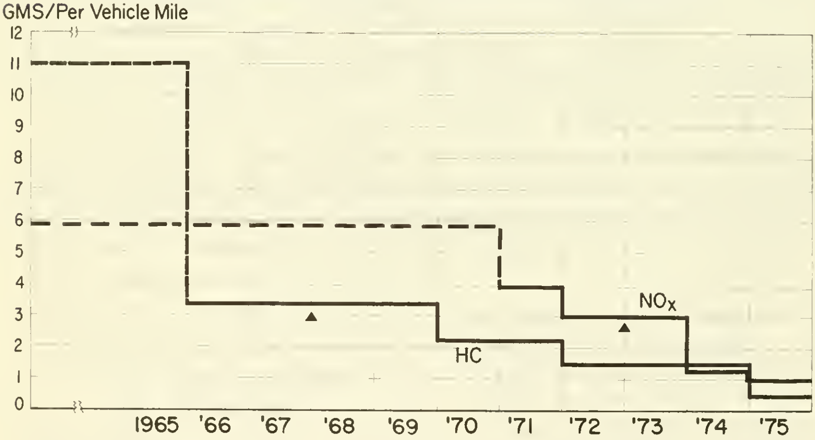
Senator RANDOLPH. Yes, we would want them included.

(The charts referred to follow:)

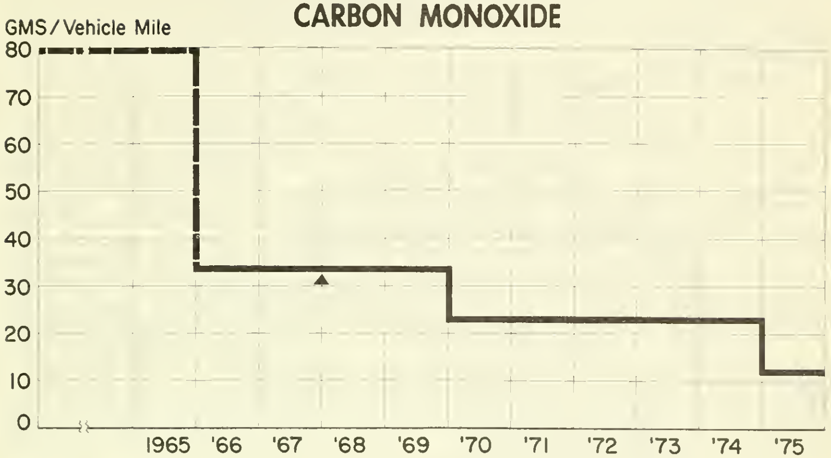
AVERAGE RESEARCH OCTANE NUMBER TRENDS AND COMPRESSION RATIO TREND



EXHAUST EMISSION STANDARDS CALIFORNIA HYDROCARBONS AND OXIDES OF NITROGEN



EXHAUST EMISSION STANDARDS
CALIFORNIA
CARBON MONOXIDE



Mr. Gammelgard. This first chart here shows the turn in premium octane numbers; the octane numbers being on the right side, the premium being the blue line here and regular grade being the lower line starting at 84 and getting up to 90 octane.

The red line has gone from a little under 7 to a weighted average of 9½. Obviously, here this is a weighted average compression ratio of new cars. Some of them are below this 9½ and can be satisfied with regular grade gasoline, some are above and require premium for satisfactory operation.

The second chart is on exhaust emissions, tailpipe emissions, that is, from carbon monoxide. An uncontrolled car at about 80 grams per vehicle mile dropping down here to less than half of that, about a two-thirds reduction going along here to the model year 1970 which it drops still further and down here this last bit is the proposed regulation for 1975. The little black dot here is the point at which Federal emission standards became effective for all new cars sold in the United States. This is quite a notable decrease from some 80 grams per mile to down in here just above 20 and that will be reduced in half by 1975.

The last chart is for hydrocarbons and oxides of nitrogen. We do not have one on particulates, but that is the other exhaust tailpipe discharge that will be controlled by 1975.

Hydrocarbons are in blue starting about 11 grams. Uncontrolled vehicle miles dropping down to here at this is which is California for 1966. At this point nationwide 1968 model cars, the same level, dropping here, dropping again, and in 1975 getting way down at this level compared to the uncontrolled car here.

Nitrogen oxide here in the red uncontrolled will not be controlled until 1971 model year. The uncontrolled car being up at this level and then dropping down here and for 1973 model year coming in nationwide on all new cars, sold in the United States, and then in 1975 the goal is for this point here.

While this is California, these points where the Federal regulations came in, they pretty much copied the California figures. There are slight differences in 1975, but there are rather insignificant differences between the California and the Federal control goals.

That concludes my statement, Mr. Chairman.

I thank you.

(The prepared statement referred to follows:)

PREPARED STATEMENT OF P. N. GAMMELGARD

My name is Peter N. Gammelgard. I am senior vice president for public and environmental affairs, American Petroleum Institute.

I would like to thank the Subcommittee, on behalf of the Institute, for this opportunity to comment on S. 3229, S. 3466, and S. 3546.

At the very outset, I would like to express our support for most of the provisions of S. 3546, "The National Air Quality Standards Act of 1970." The requirement that the states adopt and enforce air quality standards for all areas not included in federally designated air quality control regions is a logical extension of the Clean Air Act, as amended in 1967. This requirement should accelerate national progress in air pollution control and guarantee to all Americans the right to breathe clean air, no matter where they happen to live.

There are three portions of the bill in which we would like to suggest changes, however. The first of these is Paragraph (10) (B) of the proposed new Subsection 108(c), which begins on page 13, line 16.

There is no question about the need for "teeth" in air pollution control legislation. However, the penalties proposed in this bill for violations of air quality standards are, in our opinion, unduly harsh. As written, S. 3546 prescribes up to a year's imprisonment and a fine of up to $25,000 for each day of a violation and up to five years' imprisonment and $50,000 for each day of a second violation.

A more appropriate alternative might be something along the lines of the present penalty provisions of the federal Water Quality Act, as follows:

"The court, giving due consideration to the practicability and to the physical and economic feasibility of complying with such standards, shall have jurisdiction to enter such judgment and orders enforcing such judgment as the public interest and the equities of the case may require."

If the penalties are to be spelled out in the statute, however, then we urge that they be reduced substantially—to perhaps 30 days' imprisonment or $10,000, or both, for any violation, but certainly no more than this for a first offense.

The second portion of S. 3546 that troubles us somewhat is Paragraph (13) of proposed Subsection 108(c) (12) (C), which begins on page 16 line 22.

Any individual or class of individuals has the right to seek injunctive relief through the courts from any activity that is allegedly damaging to his, or their, life or property. We can see no special reason why actions involving alleged air pollution damage should originate in federal courts, or why such actions should even be mentioned in this legislation. Paragraph (13) could well open the door to a rash of irresponsible nuisance actions alleging damage where none can be substantiated.

As written, Paragraph (13) would seem to imply that State and local agencies may not adopt and enforce air quality standards that adequately protect the public. However, under the present law and the amendments contained in this bill, it is the responsibility of the Secretary of Health, Education, and Welfare to see that they do. If citizens are forced to go to court, then the Clean Air Act will have failed.

We are puzzled by the proposed new Subsection (i) in Section 108, which begins on page 17, line 14. This subsection would require "the latest available pollution control techniques" to be applied on all new stationary sources, and it would authorized a program of Federal certification of those sources.

This proposal appears to us to be inconsistent with the Air Quality Act of 1967, under which the states are to establish emission standards—for new as well as old installations—based on what is required to implement their air quality standards. A blanket federal requirement for all new sources would preempt state authority as regards those sources.

Increasingly—and this is certainly true of oil refineries—new installations are incorporating the most efficient pollution controls they can find, even though those controls may go beyond legal requirements. This is done in anticipation of the need to meet tighter emission standards in the future.

We believe government should limit its role to setting performance standards for emissions deemed necessary for protection of public health and welfare. Methods of meeting those standards should be left to the ingenuity of industry. This will tend to encourage innovation and minimize costs.

I would like to turn next to S. 3229, "The Air Quality Improvement Act." Sections 202 through 209 are a reasonable extension of federal authority over motor vehicle emissions to include other mobile sources of air pollution, and we support them.

When a federal fuel additive registration program was first proposed in 1967, I testified before this subcommittee that the Secretary of Health, Education, and Welfare should be given access to the information he needs to evaluate the possible air pollution significance of fuel additives. That is still the industry's position, and we fully endorse the registration program in the form authorized by Congress in the 1967 amendments to the Clean Air Act. The language of Proposed Section 210 of S. 3229 is identical to that adopted in 1967, and we urge that this language be retained.

In 1969, to assist the National Air Pollution Control Administration in determining the scope and extent of fuel additive use, API surveyed the industry and provided gross figures on total additive use, types of additives, and their basic chemical components. To date, the Secretary of HEW has not designated any fuel or additive for registration, but the petroleum industry stands ready to cooperate fully with the Secretary in the implementation of the program.

The proposed new language of Section 104(a)(2)(B) indicates that only *alternatives* to the internal-combustion engine are to be included in federal research on low-emission vehicles. We believe that government, in the interest of finding the best solution to the problem, ought not to exclude *any* type of vehicle or energy source from its consideration. All types of engines, including gasoline engines, ought to be able to compete to meet low-emission performance standards.

We have no specific comments to make on proposed new Section 212(a), entitled "Solvents." Although a number of API member companies are manufacturers of solvents, this matter does not fall within the normal purview of the Institute's activities. Those of our members who have an interest in this matter are also members of the Manufacturing Chemists Association, and would endorse the position taken on Section 212(a) by Mr. Willard Bixby when he testified here last Friday.

We believe proposed new Section 201 of S. 3229 relating to noise pollution studies is timely. Public concern over the problem of noise and its control certainly justifies attention from the federal government.

I would like to turn now to S. 3466. Enactment of this bill, which would authorize direct federal establishment of air quality standards and stationary-source emission standards, would be a departure from the basic approach contained in the Air Quality Act of 1967. That Act now provides for air pollution control on a regional basis, with the states setting standards under federal surveillance. In our view, the present law, with adequate implementation and enforcement, can and will get the job done. We do not believe it wise to abandon one approach in favor of another until the first one has been given a proper chance to prove its effectiveness. To do so might well result in further delays in implementing the basic objectives of the Clean Air Act.

Moreover, it should be pointed out that direct establishment of emission standards for stationary sources is contrary to the declaration of policy contained in the Clean Air Act—namely, "that control of air pollution at its source is the primary responsibility of states and local governments."

As could be inferred from our support of Section 210 of S. 3329, we do not favor granting the federal government authority to establish standards for fuel composition or additives, as is envisioned in S. 3466.

In the field of automotive air pollution, we believe that direct government regulation of manufacturing methods or gasoline composition is not in the public interest and that the federal government's role should be to establish emission standards. If compliance with those standards is left to industry, it will encourage innovation and should result in lower costs to the public.

If a reduction in any specific type of emission, including an additive combustion product, is deemed necessary to protect public health and welfare, an emission standard, together with adequate lead time for compliance, can accomplish this. In this connection, we believe HEW is to be complimented on having already announced its plans for 1973 motor vehicle emission standards and for having recently published in the *Federal Register* proposed standards for 1975. This shows on understanding of the need for sufficient lead time to make major changes in production methods.

To help put the problem of motor vehicle air pollution in perspective, I would like to take just a few moments to show the Subcommittee three charts.

These charts show quite clearly, I think, that the present system of federal regulation of automotive emissions *is* working—and without any direct federal specification of automotive hardware or fuel composition.

Emission standards for new motor vehicles have resulted in measurable air quality improvements in those congested urban areas, like Los Angeles, where the problem has been most critical. The improvement is not so rapid as we would like because of the impracticability of imposing emission standards retroactively on older cars. Thus, even if an absolutely pollution-free car were available today, the automobile air pollution problem would be with us for a number of years, until older cars without air pollution controls were phased off the roads.

In closing, I would like once again to state our support of the present provisions of the Clean Air Act, as amended in 1967. We believe it is more desirable to build on the foundation already laid down in this legislation than to substitute an entirely new approach. Therefore, with the few amendments we have suggested, we urge enactment of both S. 3546 and S. 3229 and suggest that no action be taken on S. 3466.

Thank you for your attention.

Senator RANDOLPH. I understand, Mr. Gammelgard, that, in essence, you are saying to the members of the subcommittee that you believe, within the framework of the Clean Air Act, as amended in 1967, that we can do the job necessary to be done through amendments, of course, refinements, sophistications, whatever we call it. But we should work under the umbrella of that action of 1967, rather than to go off in new directions. Is that what you are saying?

Mr. GAMMELGARD. Exactly, sir.

Senator RANDOLPH. You are saying, also, that you endorse, with some amendments, not only S. 3546 but S. 3229, and you are asking the subcommittee to think very carefully before it moves in to S. 3466. Is that correct?

Mr. GAMMELGARD. That is correct.

Senator RANDOLPH. Your charts are helpful to us, and we appreciate the testimony that you have given from the American Petroleum Institute.

As a final question: Do you have an organizational structure within the Institute where there is research and development going on in matters such as you are discussing? Is this done because of pulling together certain facts and figures from other organizations, or within the Institute?

Mr. GAMMELGARD. Mr. Chairman, we have quite a research program under API sponsorship paid for by the member companies via their dues. The current year's program is at the rate of \$3¾ million. Roughly \$2 million of that is in a program through the Coordinating Research Council, which is also financed, in addition to our \$2 million, by the Automobile Manufacturers Association and to a large degree by HEW. The oil companies themselves do millions of dollars of research in their own labs on a more proprietary basis.

Senator RANDOLPH. Mr. Gammelgard, as I discussed with Mr. Gunness and his associates, we would want you to give further information which you think might be helpful to the subcommittee in its efforts.

You know we are moving forward with 3 weeks of hearings. These have been running daily. This is not going to be an easy job. It is a complex problem. Just yesterday, we finally completed in the Senate the conference report on S. 7, the water pollution bill, and that was by a vote of 80 to nothing. So even though we worked for 5, 6, 7 months, when you come out finally with no one against you, that is better than improvising along the way even though it is a slow process.

This afternoon, I understand only a few minutes ago, the vote was unanimous on the conference report in the House. So sometimes if it seems that we must of necessity move slowly. It is only because we want to do this job with Mr. Gunness underscored in different language, Mr. Gunness said to make haste too quickly might add to the costs of producing waste. So we have to balance the program.

We certainly must not lessen our efforts; we must move aggressively. But we must also take into consideration the varying viewpoints built upon the technology and the research which people from private industry and government have provided.

Now, I don't mean to deprecate anyone in this process, I am only saying that we need, insofar as possible, coordination, cooperation, understanding, and enlightenment so that what we do will stand the test and will benefit the public interest.

Thank you very much.

Mr. GAMMELGARD. Thank you.

Senator RANDOLPH. I am sure that the staff will have considerable additional material relevant to the testimony here today. I believe it would be well to append these statements to the record of this joint hearing.

We will stand in recess until tomorrow at 9:30 a.m.

(Whereupon, at 2:52 p.m., the hearing was recessed, to reconvene at 9:30 a.m., Thursday, March 26, 1970.)

[Appendix follows]

APPENDIX—Part 3

(The following letters and statements have been presented to the subcommittee for inclusion in the record:)

AMERICAN MINING CONGRESS,
Washington, D.C., June 12, 1970.

Hon. JENNINGS RANDOLPH,
U.S. Senate,
Washington, D.C.

DEAR SENATOR: President Nixon has recently proposed the imposition of a tax on lead used in gasoline anti-knock additives. Although, as of this date, the Administration has not forwarded to Congress implementing legislation, the American Mining Congress wishes to express its concern over this proposal. Such a punitive tax, if enacted, could have damaging and far-reaching effects on the nation's mining industry. The question as to whether, or to what extent, removal of lead from gasoline could help resolve the automobile emission problem is still unanswered.

In support of this position, we believe you should be aware of the following:

1. A May 1970 report by the Bureau of Mines of the U.S. Department of the Interior has concluded that *unleaded* gasoline compared with *leaded* gasoline at a similar octane quality *increases*, rather than *decreases*, the total amount of smog-forming, eye-irritating emissions. With premium-grade unleaded fuels, the increase in such pollution was found to be 21 percent and, with regular-grade unleaded fuels, the increase was found to be 24 percent. A copy of the Summary and Conclusions from this report is attached.

2. The implications of removing lead from automotive fuels are currently under study by a specially appointed President's Commerce Department Panel on Automotive Fuels and Air Pollution. This panel of educators, scientists and businessmen has been studying the problem for the past two months and is not due to report until after June 30 of this year.

In view of the above, the Administration's tax proposal on lead for use in gasoline prejudges a complex subject.

The primary purpose of the proposed tax is to force the removal of lead from automotive fuels. In our judgment it would be illogical and unwise for such legislation to be enacted at this time. In a statement to the House and Senate Committees considering amendments to the Air Quality Act, the American Mining Congress on April 16, 1970, stated: "In the various contexts in which fuel consumption may contribute to air pollution, alternative approaches are or can be made available to achieve compliance with standards. Modification of fuel composition is only one alternative. Selection of the most economic and effective alternative is a proper function of, and should be left to, the private sector so long as compliance with applicable standards is achieved."

It is our firm belief that the purpose and function of government is to achieve appropriate standards of air quality, not to determine technically how those standards shall be met.

Sincerely,

J. ALLEN OVERTON, Jr.,
Executive Vice President.

BUREAU OF MINES REPORT 7390, MAY 1970, U.S. DEPARTMENT OF THE INTERIOR, ENTITLED "COMPARATIVE EMISSIONS FROM SOME LEADED AND PROTOTYPE LEAD-FREE AUTOMOBILE FUELS" BY B. H. ECCLESTON AND R. W. HURN

SUMMARY AND CONCLUSIONS

The photochemical reactivity of automobile emissions was found to be increased by as much as 25 pct when fuel was changed from typical U.S. leaded gasoline to prototype unleaded gasoline of comparable octane quality. The increase is attributed to characteristics of the blending components that were used to obtain the required octane quality without using lead.

Amounts, or weights, of the emissions differed somewhat between fuels. In the case of evaporative losses, the differences were attributed to volatility characteristics unrelated to the compositional changes for octane quality control. These losses were therefore assumed to be equal for leaded and lead-free fuels in calculating the photochemical reactivity equivalents. In the case of exhaust emissions the differences in amount may not be directly relatable to the compositional factors that are necessarily changed in reformulating fuels; they were nonetheless considered to be related to factors that could not be readily adjusted as in the case of volatility. These differences were therefore retained in calculating reactivity.

Specifically, the following were found: in all comparisons the leaded fuel provides the base of comparison:

Comparing premium grade gasolines—

Photochemical reactivity of total emissions increased 21 pct in changing to lead-free gasoline.

Exhaust reactivity (the value of interest in vehicles in which evaporative losses are controlled) was increased about 29 pct in emission using the lead-free gasoline.

Comparing regular grade gasolines—

A low-olefin lead-free fuel yielded evaporative losses reduced by 31 pct but at the same time exhaust reactivity was increased by 38 pct; the result is that total reactivity was increased 7 pct.

A lead-free gasoline with average olefin content yielded evaporative loss reactivity increased by 28 pct with a parallel 21 pct increase in exhaust reactivity; total reactivity was increased by 24 pct.

Emissions of carbon monoxide, oxides of nitrogen, and aldehydes were not affected significantly by the changes from leaded to lead-free fuel formula.

It is emphasized that these results are not related to the effect of lead, per se. They bear only upon the emissions characteristics of fuels and the influences of fuel components. The findings are therefore related to use of lead only insofar as fuel formulation is related to the use of lead.

ASHLAND OIL & REFINING CO.,
Ashland, Ky., June 15, 1970.

HON. JENNINGS RANDOLPH,
U.S. Senate, Washington, D.C.

DEAR SENATOR RANDOLPH: This is to register in the strongest terms our opposition to the Administration's proposed tax of $4.25 a pound on lead used in motor fuel additives.

The grounds of our opposition are set forth in a statement by Robert E. Yancey, our Chief Operating Officer, released to the press on June 1, 1970. A copy of the press release is enclosed for your information.

As pointed out by Mr. Yancey, the proposed tax would add some 2.3 cents a gallon to the cost of leaded gasoline, and to eliminate lead additives, the oil industry would be required to spend enormous sums estimated to be of the order of 4 to 6 billion dollars for new facilities and equipment. These costs would push gasoline prices up sharply and promptly, increasing the cost of living for almost all American families.

Additional adverse effects of the proposed tax to which Mr. Yancey's statement calls attention include the following:

(1) Crude petroleum, a vital natural resource already in limited supply, would be consumed at an accelerated rate and thus wasted as a result of the proposed tax and consumer costs thereby further increased; these grave consequences follow directly from the fact that the processes required to make lead-free, high-octane gasoline diminish the yield of gasoline per barrel of crude oil and, in addition, such gasoline provides fewer miles per gallon.

(2) Imposition of the tax would prejudge issues as to air pollution from automotive emissions which are still under study: indeed, these studies indicate that complete elimination of lead prior to attainment of proper engine design could increase pollution through engine inefficiency.

(3) Maintenance of current octane requirements without lead additives would require greater use of aromatic hydrocarbons which would increase pollution.

(4) Even with the temporary relief afforded smaller refining companies, independent refiners whose plants are generally of small or medium size would suffer severe and immediate burdens, as contrasted with the major oil companies whose plants are usually of much larger size, often with more sophisticated equipment, representing heavy capital investment beyond the reach of independent companies.

Concluding, Mr. Yancey emphasized that the industry does not oppose stringent pollution control standards, but urges an orderly program to accomplish control goals, giving full consideration to economic impact.

Clearly, a tax on lead in this context must be characterized as an unsound and discriminatory attempt to raise revenue under the false guise of pollution abatement.

We trust that you will concur in our judgment that the public interest requires the rejection of this ill-considered measure. We shall greatly appreciate your consideration.

Our representatives will be available to discuss this matter with you at your convenience.

Cordially,

William J. Hull,
Vice President.

Lead Tax Proposal Inflationary, Could Bring More Air Pollution, Ashland Oil Officer Asserts

Ashland, Ky.—The administration's proposed tax on leaded gasoline almost certainly will force auto motor fuel price increases well above the added cost of the tax itself; this will put a heavy new burden on the consuming public and heighten inflationary trends in the United States.

Moreover, according to Robert E. Yancey, chief operating officer of Ashland Oil, Inc., and president of its Ashland Petroleum Company division, passage of the tax proposal could tend to increase air pollution rather than reduce it.

Mr. Yancey noted that the tax would add some 2.3 cents a gallon to the cost of leaded gasoline; and the oil industry estimates that in order to eliminate lead additives, from $4 billion to $6 billion will have to be spent for new facilities and equipment.

These costs would necessarily push retail gasoline prices up sharply and promptly, he added.

The proposal, Mr. Yancey continued, obviously is intended to produce revenue rather than abate pollution.

It also has been established, he said, that lead-free gasoline affords the motorist fewer miles per gallon; and at the refinery there is a considerably lower gasoline yield per barrel of crude oil when processes for making lead-free motor fuels are required. These and other factors combine to accelerate the use of crude oil, thereby promoting waste of a valuable natural resource already in limited supply, and adding further to consumer costs.

"Any legislation forcing rapid change should give serious consideration to the economic impact that could result," he said.

President Nixon's May 19 announcement that Congress would be asked to enact the tax had the effect of pre-empting studies in progress by the Commerce Department and the Department of Health, Education and Welfare concerning air pollution from automobile emissions, Mr. Yancey continued. Many oil companies contributed information to the administration-initiated studies and cooperated in their efforts, but no conclusions on proper courses of action had been reached by the departments.

Extensive studies have failed to show that lead anti-knock compounds present a health hazard, the Ashland officer said; and automobile manufacturers have stated that current engines give better performance using gasoline with tetraethyl lead.

This could indicate that the elimination of lead before proper engine design is attained could increase pollution through engine inefficiency.

Automobile manufacturers have indicated that it will be 1974 before cars can be manufactured that will meet proposed emission standards, as no muffler system has as yet been developed commercially that eliminates the unburned hydrocarbons in the exhaust.

A further complication of the situation predictably will come as oil companies alter gasoline bleeding components used in meeting current octane requirements. Mr. Yancey said. The reduction of lead additives will require greater use of aromatic hydrocarbons to hold octane ratings up; and studies already have indicated that these aromatic hydrocarbons increase pollution regardless of the lead content of the gasoline.

These components now are widely used as intermediates in the production of plastics, fibers and chemicals. Diverting significant amounts to gasoline production will have further impact on the public, as it will drive up prices of consumer products made from these materials.

Furthermore, the tax proposal is inequitable. Mr. Yancey continued, its real cost to refiners will vary widely. This will result from the fact that refiners use different lead-additive contents to meet their own requirements for octane, depending on their processing facilities and the types of crude oil available to them.

Even though the proposal includes provisions for easing the impact on smaller refining companies by allowing them to produce leaded gasoline tax-free for a limited period of time, the burden on a company with several small to medium-size refineries is immediate, he pointed out.

Another aspect of the proposal is the manner in which it focuses on only one material, Mr. Yancey said. If this tax is enacted, he noted, other and more evident sources of pollution also could be taxed, thereby creating a "snowball effect" that could be even more onerous to the consuming public and to industry.

"Industry doesn't oppose stringent pollution control standards," he said, "and an orderly program can be developed that will accomplish these control goals. It must be carefully planned and implemented, however, with full consideration to the economic impact it will have."

Mr. Yancey is immediate past president of the National Petroleum Refiners Association, and has served as a member of the Air and Water Conservation Committee of the American Petroleum Institute and the Environmental Conservation Committee of the National Petroleum Council.

A director of Ashland Oil as well as its chief operating officer, he became president of Ashland Petroleum Company at the time of the division's formation in late 1969.

HUSKY OIL CO,
Denver, Colo., May 7, 1970.

Hon. CLIFFORD P. HANSEN,
U.S. Senate, Senate Office Building,
Washington, D.C.

DEAR SENATOR HANSEN: At about the time we were talking to you regarding special problems in the Rocky Mountain area of phasing-in low lead content gasoline, one of the large oil companies was giving Secretary Finch their views. They advocated a three-grade system, one which would be a new 91 RON containing no or low lead content, and the other two would be the same as now marketed. As far as I could tell they did not advocate any time limit for this system.

Their stated reason for this view is that many current automobiles that operate on 94 RON leaded fuels now will not operate on a 91 RON gasoline unless they are derated by extensive adjustments. They argue that the public is just not likely to do this and therefore, they advocate the continuance of the current two-leaded grades with addition of a new 91 RON low or no lead fuel. Some other large majors have made similar statements.

Although there is unquestionably merit to their argument for cars operating on the East and West coasts of the U.S., it does not apply equally to the high altitude Rocky Mountain area. The great majority, if not all cars that now operate properly on leaded regular gasoline in our area will operate quite satisfactorily on a low lead 91 RON gasoline. What we need out here to comply with the nation's desire to reduce pollutants by automobiles caused by lead, is time to phase-in due to the economic impact involved, particularly on the small refiners and assurance that the car manufacturers will not start another octane race after passage of fuel composition legislation. Generally, our clear octane pool capability is lower than in other parts of the country because it has not been needed.

The three-grade approach would do little to reduce lead emissions for a long time but would impose hardships on the two-grade refiners and marketers.

It should be clearly understood that Husky, in no way, wants to say how many grades a given marketer should have, that is his choice. Conversely, however, we do not want to see a system that actually requires more than two grades imposed on the Rocky Mountain area affecting many small distributors and refiners when it is not needed. Cars can operate on three to five less RON fuels at Rocky Mountain altitudes.

In summary, I would like to see any legislation encompass the following points if gasoline composition controls are enacted:

1. That the Secretary of Health, Education & Welfare be limited to regulating the additives contents of gasoline for the present.

Certainly he should be in a position to request reporting of research on other components to determine whether additional legislation might be required in the future.

2. The bill should give the Secretary the power to regulate manufacturers of passenger cars so that the cars do not require more than a 91 RON octane gasoline. This could be stated this way or be controlled by a compression ratio of say 8.5/1 maximum.

3. That the Secretary be empowered to set up phased-in dates by PAD Districts for mandatory compliance of the maximum lead content of fuels. (PAD 4 includes Wyoming, Montana, Utah, Idaho and Colorado.)

4. The bill should instruct the Secretary that nis initial program should be to have the industry (a) provided a regular grade of gasoline of 91 RON containing not more than ½ gram of lead per gallon, and that this lead content be maintained as a maximum indefinitely until research proves otherwise and (b) provide a premium gasoline of 97 minimum octane that could contain up to 4 grams of lead per gallon as long as needed. Other grades of lower or higher RON gasolines up to 97 RON could be marketed provided they contain no more than 0.5 gram of lead per gallon.

What I am proposing, would work in the Rocky Mountain Regions without question and will not require the derating of automobiles. It will work in other areas also, with a minimum economic impact on refiners, marketers and the consumer. It will, however, require that the industry be given time to get the job done. In our repy to Secretary Finch's recent inquiry, we urged that the date for compliance in the Rocky Mountain area be at the earliest, July 1, 1973.

By giving the Secretary of HEW the authority to set target dates by PAD Districts would mean that he could give the Rocky Mountain area until July 1, 1973, but require earlier dates if he so chooses for say, PAD Districts 1 and 5 where the octane capability of many of the refiners would permit compliance without excessive costs.

This is a major problem. When one considers that the new year models will constitute only 7% of the car population, and that the most severe emission standards will not become effective until the year 1975, it seems to me that the industry does have time for an orderly change rather than a stampede which will accomplish nothing. I agree, however, that target dates must be met.

Cordially,

ARTHUR B. HERSBERGER,
Executive Vice President.

STATEMENT SUBMITTED BY J. L. KIMBERLEY, EXECUTIVE VICE PRESIDENT OF LEAD INDUSTRIES ASSOCIATION, ON SENATE BILL 3229 SECTION 210 AND SENATE BILL 3466 SECTION 5

As executive vice president of the Lead Industries Association, I am submitting this statement on behalf of our 62 member companies engaged in the mining, production, manufacturing and fabrication of lead and lead products.

Senate Bill 3229 Sec. 210 and Senate Bill 3466 Sec. 5 would have serious ramifications for the lead industry as well as many other important segments of U.S. industry. This section of the bill would empower the Secretary of Health, Education and Welfare to register and regulate fuels and fuel additives. This is of particular concern to the lead industry because lead antiknock compounds are the major additive in today's gasoline. We oppose the granting of this power for reasons given below.

We have monitored your subcommittee hearings and heard many inaccurate contentions and accusations pertaining to lead additives. We will endeavor to state our position in light of the material you already have before you.

We commend and support all efforts to reduce harmful emissions into the air from automobiles and other sources. However, we question that it is necessary to give the Health, Education and Welfare Secretary the broad power of determining how fuels shall be made. His concern is properly what is *emitted* from an auto exhaust—not what fuel combinations or control systems achieve low emissions. Banning lead will not in itself accomplish control of major automotive emissions. Indeed there is good evidence that removal of lead may even increase certain noxious gaseous emissions.

Much progress has been made on developing emission control systems that will work with leaded gasoline, whereas we do not know of any systems that have been tested out to work with non-leaded gasolines.

The California Air Resources Board has completed tests on a Du Pont thermal reactor system on a conventional automobile that came well under the 1975 goals set by that State and the Federal government and came near to meeting the 1980 goals. And this was with leaded gasoline!

We are told the official results on a Du Pont system showed hydrocarbon emissions of 0.22 grams per mile, compared with the 1975 California standard of 0.50 grams per mile, and the 1980 Federal goal of 0.25 grams per mile. Carbon monoxide emissions in the ARB test were 7.4 grams per mile, compared with the 12.0 grams per mile set in the 1975 California standards and the 4.7 grams per mile projected in the 1980 Federal goal. Oxides of nitrogen emissions from the reactor-equipped car, with a supporting exhaust gas recirculation system, were 0.41 grams per mile. This compares with 1.0 grams per mile in the 1975 California standards and 0.4 in the 1980 Federal goal.

If the Health, Education and Welfare Secretary were to ban lead additives, he might be shutting off the very real possibility that more complete emission control could be accomplished soon with present cars and gasoline. The banning of leaded gasoline might well leave only the unproved and undemonstrated alternative of improving emission controls with unleaded gasoline.

Furthermore, it is universally agreed that if unleaded gasoline is mandated, the public would have to absorb the higher cost of motor vehicle operation, and that the draw down of petroleum reserves may be increased by as much as 6 to 8 percent per year.

This uncharted course will seriously affect the petroleum and automobile industries and their customers as has already been testified. The lead industry also would be adversely affected. Lead for gasoline additives accounts for 20 percent of total annual lead consumption in this country, and a much higher percentage of all lead mined in the United States. Significant as this market is to the lead industry, I am authorized to say that we would withdraw our objections to the removal of lead from gasoline if we were convinced that this is necessary to solve the auto emission problem or if lead's removal were necessary to remove a known health hazard to the public.

We are not convinced that the removal of lead will have all the benefits purported.

For these and other reasons which I will discuss, we urge you not to enact legislation that would put such power in the hands of the Department of Health, Education and Welfare.

In support of our position, I offer these major points for consideration:

First: It is astounding to find gross misconceptions, misrepresentations and false conclusions are being used officially to support the drive to "get the lead out." A document that was used as a guide for California legislators in recent hearings contains examples, a few of which I will cite shortly.

Second: The most advanced emission control devices that have actually been demonstrated—and are presently available for adapting to mass production for use on present cars have been shown to be effective with today's leaded gasolines. Auto industry testimony before the subcommittee substantiates this.

Third: No clear definition has been given of any presently developed system that will be used with non-leaded gasolines to control the truly noxious emissions that are the major target of this abatement effort.

Fourth: As a corollary to the third point, there is considerable belief, and evidence to support that belief, that non-leaded fuels could actually increase, rather than decrease, the more noxious and obnoxious auto fumes. This is a vast unknown that is being ignored by many.

Fifth: All the problems involved in removing lead would be worth tackling if there were to be shown any need for getting lead out of gasoline on the grounds of public health or even nuisance. Lead is not involved in photochemical smog formation, nor in irritation of eyes or other membranes, nor has lead in the air, from whatever sources, been shown to present a danger to public health.

Sixth: As to control of particulate emissions from auto exhausts in the future, this is the fuzziest area yet encountered. So far as I can find, no one has defined what is even meant by "particulates." This is important because lead alone amounts to about one-third and probably no more than 40 percent of total auto particulate emissions. Thus even the complete removal of lead from gasolines would not in itself achieve the particulate emission goals projected by the Federal government. Nevertheless, we believe it is important that any control systems should include control of particulate emissions. And such controls are part of most test systems being demonstrated today particularly by Du Pont and Ethyl Corporation. Even so, the particulate problem is admittedly a small part of the total auto emission problem.

I would like to elaborate on some of these points. As to the first, my comments refer to a document entitled "Lead and Gasoline" which was used to brief members of the California Assembly Transportation Committee before whom I appeared April 2. After seeing this misleading material, I can better understand why some legislators believe they should act against leaded gasoline.

This document says: "The auto manufacturers have supported the removal of lead from gasoline; the oil industry has promised to provide unleaded fuel when it is needed."

My comment is: The implication of enthusiastic support is very suspect. My information strongly suggests that the auto industry acted under the pressure of the emission goals projected for 1975 and 1980. They singled out lead for a dramatic statement without giving much more than a promise that removing lead would ease the way for them to meet the later control standards. In fact, this was confirmed by the auto companies in recent Washington subcommittee hearings. Certainly the oil companies did not respond enthusiastically or even unanimously. Small refiners are faced with huge problems, including the possibility of being forced out of business. But the major companies are saying they can provide non-leaded gasoline—at a cost—if the demand is there.

The briefing paper used in California starts out with these statements or rather, mis-statements: "The human body has no beneficial use for lead. Yet each year the concentration of lead in the bodies of people living in our metropolitan areas is increasing. Most of the lead in our bones has been assimilated out of the air we breathe."

Each one of these sentences is prejudicial and either misleading or erroneous.

As to the first, it is not known whether or not the human body has beneficial use for lead. Admittedly, no such use has been shown to date. But it is only in recent years that the role of trace metals in biology has been studied and understood. It is now known that metals such as iron are necessary to body functions in amounts of about 6 grams, copper in amounts of about 250 milligrams, zinc in amounts of about 3 grams and so forth. Yet each of these essential metals can also be toxic in excessive amounts. Thus the acknowledged fact that excessive amounts of lead can be toxic does not rule out the possibility (now being studied) that the small amounts of lead normally found in human bodies may not perform some necessary function.

I know of no evidence to support the second sentence that the concentration of lead in people in cities is increasing yearly. Published evidence generally belies that statement. It is true that certain people exposed to unusual—not normal—amounts of lead may show increased lead levels in their blood. But in tests among the general public lead levels are shown to be well within the normal safety range.

On the third statement saying that most lead in bones comes from air, I know of nothing to support it. Carefully controlled studies of lead intake by human beings over a number of years have established that the major sources of lead entering the human body are food and drink—most of it from naturally occurring sources. And lead excretion from the body generally balances with lead intake.

There are other such prejudicial statements intended to incite action against lead. I will comment on only one more.

The document says: "Health officials fear that, if we wait until toxic concentrations are reached, we may be faced with widespread lead poisoning before the situation can be reversed."

This raises an emotional spectre for which there is no rational basis. I know of no evidence that lead in the ambient air is sustained at levels near the proposed ambient air standard of 10 micrograms per cubic meter of air on a 30-day average.

This standard, as recommended by the American Industrial Hygiene Association, in itself has a large built-in margin of safety. Further, experience in lead industrial installations where the accepted threshold limit value is 200 micrograms per cubic meter of air for a work week has demonstrated that "widespread lead poisoning" does not occur at these levels or even higher levels that may sometimes be reached under certain work conditions.

Referring to the points on control systems, it is strange that so much reliance is placed on rather vague promises of emission control approaches that may be developed after there is lead-free gasoline. Stranger still is the delay in adopting and improving control methods that have already been shown to work with existing gasolines and automobiles.

It stands to reason that if the emotional drive succeeds to force the automobile public to use non-leaded gasoline, this may well close off one promising alternative to the solution of automobile exhaust problems. Today the most advanced and demonstrated methods for such emission control work with leaded gasoline. Should leaded gasoline be banned, obviously research on and further development of such systems compatible with leaded gasoline will be greatly hampered, if not brought to a standstill.

The uncertainties about results if non-leaded gasoline is required emphasize the need to be sure the Health, Education and Welfare Secretary does not have arbitrary power over additives. Dr. Richard D. Cadle of the National Center for Atmospheric Research, and a recognized authority on the composition of the atmosphere, explained his concern in the April 20, 1970 issue of *Chemical & Engineering News:*

"In connection with any possible health hazard from the lead compounds that automobiles send into the atmosphere, Dr. Cadle believes that there is reason for alarm, but warns that quick solutions could build into problems of an entirely different stripe. He suggests, for example, that gasoline manufacturers who hope to replace leaded alkane gasoline with high-aromatic fuels should look at least twice before they leap.

"It's conceivable that some of these aromatics could lead to the formation of carcinogenic by-products in the combustion process, although I don't know of any hard evidence to support that idea. Nevertheless, aromatic compounds generally are toxic, irrespective of whether or not they're carcinogenic.

"Also, certain aromatic compounds have been found to be a couple of orders of magnitude more severe as eye irritants than the peroxyalkyl nitrates formed from conventional gasolines. What I'm really saying here is that in the whole area of air pollution control, we shouldn't rush ahead with one solution before trying to anticipate the larger problems it may create."

We have raised these points in our conviction that unless it can be satisfactorily demonstrated that lead's removal from gasoline will greatly facilitate the control of noxious emissions, there is no urgent reason for seeking a ban on leaded gasoline. This is particularly true since there will apparently be no additional control devices on new cars for at least two more model years.

The lead industry has pioneered in research on occupational and other hazards from overexposure to certain lead compounds. We continue to support and press for expertly planned and executed studies on health aspects of lead in the environment, including the atmosphere. Such studies are being carried forward now, by the International Lead Zinc Research Organization alone or cooperatively with the U.S. Public Health Service, the American Petroleum Institute and others.

Before final decisions are made on lead in gasoline, either by legislation or government pressure, we urge further careful study and development of:

I. Existing methods for reducing undesirable gaseous automobile emissions with systems that are known to work with present gasolines.

II. Techniques and devices that will reduce all particulate emissions from gasoline, including lead.

III. Polluting effects including adverse health effects if automobiles are forced to use non-leaded gasoline.

In view of all these uncertainties, we feel no action should be taken to empower the Secretary of Health, Education and Welfare to ban the use of lead additives until there are proven benefits or a demonstrated need far more definite than exist today—particularly without full hearings, without proper coordination, and without complete knowledge.

STATEMENT OF MOBIL OIL CORP. ON S. 3466

This statement is submitted for the purpose of presenting Mobil Oil Corporation's views on those provisions of S. 3466 which relate to motor vehicle emissions.

Mobil's objective in connection with such emissions was stated in its reply to the letter Secretary Finch sent to the petroleum industry soliciting views on automotive emissions control. In that letter, Mr. Rawleigh Warner, Jr., Chairman of the Board, stated the following: "We have tried to direct our conclusions toward goals of reducing pollution while protecting the economy from unnecessary construction inflationary pressures and the consumer from unnecessary increased expenditures." A copy of Mr. Warner's reply is attached.

The focal point of current discussion on emission control is the role of lead in gasoline. In this regard, we call your attention to the fact that three years ago in a publication published by Mobil, called "A Primer on Air Pollution," we made this statement: "If getting the lead out is going to be the most effective, economical way of beating pollution—which nobody knows yet—Mobil will get the lead out." Our research and analysis over the past three years would lead us to make the same statement today.

In order to help find the necessary answers, Mobil initiated with Ford Motor Company the Inter-Industry Emission Control Program—IIEC, for short. This is one of the largest private ventures of its kind. It now includes nine other petroleum and auto manufacturing companies. The targets for the program, established almost three years ago, are similar to the 1975 goals proposed by HEW almost three months ago.

With this as a background, we will review the key issues that have been raised in connection with reduction or removal of lead in gasoline, as set forth in Secretary Finch's letter of March 20. In that letter, Secretary Finch outlined the following suggested course of action:

1. After July 1, 1971, gasoline marketed in the United States would contain no more than 0.5 grams per gallon of lead unless its octane rating were at least 97;
2. After July 1, 1974, gasoline marketed in the United States would contain no lead unless its octane rating were at least 97;
3. Gasoline of 97 or greater octane levels would contain up to four grams per gallon of lead so long as the demand for such gasoline existed.

In connection with this suggestion, we feel there are four areas which should be examined very carefully. These are:

1. The balancing of the fuel needs of existing cars with those of new cars;
2. The number of grades of fuel which should be available to the consumer;
3. The probable useful life and replacement cost of catalytic and thermal afterburner emission control systems;
4. Analysis of the advantages and disadvantages of lead for new and existing cars.

I. THE BALANCING OF THE FUEL NEEDS OF EXISTING CARS WITH THOSE OF NEW CARS

The introduction of any new fuel system must not only take into consideration new cars but the 100 million cars presently on the road. It is our conclusion that the overwhelming majority of these 100 million cars will continue to require gasoline at today's octane levels and containing some lead. It is our understanding, from auto industry technicians that the high temperature at which exhaust gases emerge from the engine render conventional lubricants for exhaust valves ineffective. Lead, however, forms compounds during combustion which satisfactorily lubricate these exhaust valves in the engine. The absence of lead would cause the valves to wear or "pound-in" valve seats, thereby resulting in an imperfect fit at the moment the engine is fired. The first major effect of this "pound-in" is a drastic increase in emissions of hydrocarbons and carbon monoxide, as unburned gases escape prematurely from the cylinder. We are further advised that as this "pound-in" continues, gasoline mileage and fuel losses result and eventually severe engine damage can result. Ford Motor Company in testifying before this Committee on March 25th, referred to this problem when they said "complete removal of TEL (anti-knock fuel) or complete reduction of TEL levels at 0.1 or 0.25 cc's per gallon would cause serious deterioration of engine's ability to function."

General Motors publicly described this problem in a paper presented to the Society of Automotive Engineers in 1969, as follows:

"It became evident that the exhaust valves and seats were sensitive to speed and load conditions operating on non-leaded fuel . . . extreme exhaust valve seat wear was experienced on (the) two sets of cylinder heads in Car A when operated on a high speed schedule. The effect of non-leaded fuel on exhaust valve and seat life must be more definitely determined."

Chrysler and American Motors similarly referred to this exhaust valve problem in testimony before the House Subcommittee on Public Health and Welfare.

One company has marketed unleaded gasoline for some years in a limited number of stations along the East Coast. We believe the principal reason that the valve "pound-in" problem has not surfaced widely in this connection, is that the limited number of locations at which the unleaded gasoline is available results in the consumer, occasionally, buying leaded gasoline. This supplies sufficient lead compound lubricant on the valves for protection to the next unleaded gasoline purchase. Another reason is that purchasers of this unleaded Premium gasoline, at extra cost, are generally owners of higher priced, larger engine cars. These big engines. which have considerable reserve power, are less susceptible to "pound-in" than the smaller engines that have to operate at their maximum power more frequently.

If we move to a no-or-low lead gasoline in 1971, the only economically feasible method of meeting octane needs would be through the accepted processing procedures which result in increased aromatics. The principal method developed to date for adding octanes to gasoline to replace those lost through lead removal, is through "reforming" gasoline molecules to higher octane "aromatic" compounds. We have some worry concerning possible pollution implications of increased aromatics unless the cars using the fuel have reliable emission control equipment.

A recent Bureau of Mines report concluded: "The fuel alterations from leaded to unleaded gasoline changed emission characteristics so that the pollution effect was increased by as much as 25%." The author of this report, the Project Coordinator for the Bureau of Mines, Mr. Richard Hurn, qualified that conclusion in recent testimony in California to the effect that any switch to unleaded fuel *could* increase aromatics and other pollutant emissions as much as 38%. According to an official of the Los Angeles Air Pollution Control Board, aromatics has an impact on smog and he questioned the desirability of increased aromatics in gasoline unless it is prevented from going into the atmosphere. Aromatics will not be a problem in 1975 model cars because the advanced controls targeted for these cars will prevent their escape to the atmosphere.

II. THE NUMBER OF GRADES OF FUEL WHICH SHOULD BE AVAILABLE TO THE CONSUMER

The suggested course of action essentially proposes a two-grade system based on a new 91 octane low-lead fuel and a 97 or higher premium with today's lead content. We have analyzed that concept and compared it with a three-grade system based on a new 91 octane low-lead and today's present regular and premium octanes with today's lead levels. In view of the compression ratios in cars presently on the road, it is our conclusion, and we have stated this to Secretary Finch, that a two-grade system would require legislation precluding today's regular 94 octane leaded fuel, and in addition, would either require the majority of the existing cars to be derated, if they can be, so they could run the new 91 low-lead fuel or require the owners to pay the increased cost of using 97 or higher octane premium grade. We have very serious doubts as to whether it would be possible to mandate by legislation the elimination of the middle grade. We further question the economic advisability or the practical feasibility of either derating a major portion of the 100 million cars on the road or forcing their owners to pay for gas at octane levels beyond that which their car needs. Furthermore, as an auto industry witness recently stated before the House Subcommittee on Public Health and Welfare. in answer to a question on derating existing cars: ". . . it must be recognized, however, that the national man-hour requirements alone to modify the millions of current vehicles in use may well be staggering."

If the Government does not mandate the continuation of the two-grade marketing system, the adoption by the auto industry of a timetable which effectively will require the simultaneous marketing of a new low-grade fuel plus the existing fuel grades for the present car population, would effectively force the remaining two-grade marketers either to vacate the market for one of these grades or to make the necessary investment to market a third grade.

While Mobil Oil will probably market a third-grade fuel because of competitive considerations, this will be an expensive course for us to follow—a course which has been necessitated by the precipitate action of competitors introducing fuel changes before the devices to utilize these fuels are available on automobiles (or indeed, before they are demonstrated to be reliable in actual use). We at Mobil had believed—and indeed we still believe—that devices with a satisfactory operating interval without servicing, could be developed to operate on leaded fuels, so as to permit an orderly and long-term phase-out period in the use of lead. Such a long phase-out period would ease greatly the financial and operating burdens on the petroleum refining and marketing industries and on the construction industry, and ensure that the transition would not impair the continued viability of companies in these industries.

III. THE PROBABLE USEFUL LIFE AND THE REPLACEMENT COST OF CATALYTIC AND THERMAL AFTERBURNER EMISSION CONTROL SYSTEMS

It is our understanding that unleaded gasoline was originally requested because the auto companies had concluded that emission control equipment to be incorporated in 1975 model cars would not operate with leaded gasoline. We have questioned this conclusion before various legislative bodies and in our letter to Secretary Finch. The research we have carried out under the auspices of the Inter-Industry Emission Control program indicates that for gasoline with present lead content we now have a catalyst which will operate up to 14,000 miles. Also by use of more expensive alloys, thermal devices have been developed which have a long life with leaded gasoline. It is true that the same catalyst with unleaded gasoline runs up to 50,000. Further information developed from our research indicates that low-lead fuels containing 0.5 gram of lead per gallon appear to be about the same as unleaded gasoline in their effects on catalytic and thermal devices. Our laboratory data show that a number of catalysts would be expected to have satisfactory activity to meet the proposed 1975 Federal standards for hydrocarbon and carbon monoxide emissions for 50,000 miles when using low-lead (0.5 gram/gallon) gasoline.

The cost to the consumer of replacing the catalyst must be measured against the cost to the consumer of totally unleaded gasoline. Our preliminary analysis indicates that a catalyst replaced after 14,000 miles and possibly up to 50,000 miles with low-lead gasoline may be cheaper consumer-wise than the cost of unleaded gasoline. The auto companies would be in the best position to determine, in the final analysis, the replacement costs of these catalysts. But since emission control equipment will not be in place before 1974, we question the technical and scientific need for low-lead gasoline before that date, particularly if it results in additional uncontrolled aromatics.

However, it would be premature at this time to conclude that completely lead-free gasoline will actually be needed. Work to identify the emission control systems to be used and durability tests have not been completed.

General Motors, in testifying before the House Subcommittee on Public Health and Welfare on April 14 said in reply to a question regarding its schedule for such systems, the following:

". . . I cannot tell you when this will be, sir, as much as I would like to. We are in the position of talking about either an exhaust reactor or a catalytic converter, whichever turns out to be the most promising and offers the best bargain to the customer to get the job done. And we do not have a design at the moment that we think is final."

Later GM stated that 1975 was their target for commercial installation of such a design.

In a letter distributed to the petroleum industry on March 31 proposing an unleaded grade for 1974, General Motors, in referring to the possibility of retaining a small amount of lead, said:

"However, if a reduction in control system life would be acceptable to the regulatory agencies, a small amount of lead could remain beyond 1975. Any position on this would seem to depend on a careful analysis of the trade-off."

This analysis has not yet been made.

Such analysis should be an integral part of choosing the design that offers the best bargain to the customer as stated by GM. Included should be consideration of further reductions in compression ratio to accommodate lower octane requirements and attendant benefits in reducing emissions and costs.

Chrysler and American Motors testified before the same Committee that the work needed to select the emission control designs for 1975 model cars has not been completed. Ford, in testifying before this Committee on March 26, advised that "we are continuing our catalyst studies with gasolines containing low lead levels (e.g. 0.5 cc of lead per gallon)," citing benefits to existing cars from retaining this amount of lead.

Much of the speculation and projections of fuel requirements for 1975 model cars has been conducted on the basis of comparisons between zero lead gasolines and fully-leaded gasoline. In recent months, as the large benefits of retaining 0.5 gram/gallon lead to protect existing cars and to lessen the economic impact of lead reduction have been more fully appreciated, work on low-lead fuels has been accelerated.

Even in this short period of time, we have seen dramatic improvement in results with such fuels. As previously stated, we are finding that differences in results between using completely lead-free fuels and virtually lead-free fuels (0.5 gram/gallon) are relatively small. We quote from a report being prepared for submission to the Commerce Department's Lead Panel, at their request, by our Research Department. These are preliminary research data and should not be considered conclusive.

"So far, our tests have accumulated the equivalent of up to 15,000 miles of operation on gasolines containing 0.5 g to 3.0 g Pb/gal (as lead tetraethyl). Based on the results of these tests, we are quite optimistic about meeting . . . proposed 1975 Federal emission goals (0.5 g/mi. HC, 11 g/mi. CO), for 50,000 miles, with either a catalytic or thermal afterburner operating on low lead gasolines (containing up to 0.5 g Pb/gal)."

It should be pointed out that before final conclusions can be drawn with regard to the durability of catalysts, even with zero lead gasolines, more extensive tests must be conducted.

"Our results indicate:

"Out of a total of twenty-eight catalysts tested, which are representative of the board spectrum of catalysts tested in the IIEC program, at least three HC/CO catalysts performed nearly as well on *low lead* gasolines as on unleaded gasoline and we project that they will meet IIEC emission goals for 50,000 miles . . .

"Four potential alloys for constructing thermal afterburners have acceptable low corrosion rates in exhaust from an engine operating with low lead gasoline. One of these alloys, Hastelloy X, has already been shown to have 100,000 miles durability in the more corrosive exhaust from high lead gasoline (3 g Pb/gal). A second less expensive alloy, OR–1 (nickel-free chrome steel) has low corrosion rates with low lead fuel comparable to that observed with unleaded gasoline."

Time is needed to complete these tests and we recognize the sense of urgency. However, time must be available to complete the work that the auto manufacturers have stated needs to be done. We feel such work is essential to reach the appropriate systems decision for 1975 model cars if the best interests of the consumer are to be served.

IV. ANALYSIS OF THE ADVANTAGES AND DISADVANTAGES OF LEAD FOR NEW AND EXISTING CARS

In 1974, two-thirds of the cars produced up through the 1970 model year will still be on the road. The dangers of making completely unleaded gasoline available to these cars in terms of increased emissions, lower power and mileage and catastrophic engine damage, as described by auto manufacturers, were covered earlier. The retention of a slight amount of lead, on the order of 0.5 gram/gallon will largely avoid these problems.

Beyond this, the economic benefits of keeping this slight amount of lead in gasoline are large. The initial small amount of lead added to gasoline provides the largest boost in octane number. Successive additions provide progressively smaller octane increases. This effect is so large that 0.5 gram of lead per gallon would save more than half the cost of producing completely lead-free gasoline of current quality.

Retaining 0.5 gram of lead, therefore, would offer large relief from the economic strains of meeting future emission control requirements. If an unnecessarily rapid or too drastic a lead reduction program were undertaken, several undesirable results are likely.

A substantial inflationary impact can be foreseen on the economy in the scramble to build new refining facilities. Delivery of major refinery equipment units even today is on delayed schedules.

The problem is aggravated further by the fact that three-fourths of U.S. refinery capacity is concentrated in four areas. The Gulf Coast, California, the Delaware Valley and the five-state area around Chicago. Because skilled craft labor is already in short supply in these areas, chaotic inflationary conditions are likely to result from accelerated major construction programs of the type that can be foreseen with zero lead targets.

Small refiners have testified in California and Washington that too rapid a program to zero lead gasoline would put them out of business because of their lower octane capability and relatively large capital requirements.

To the degree that all of these economic pressures can be alleviated by tailoring lead reduction to actual needs, the consumer and the nation will benefit.

It is our view that, on balance, the advantages of lead to the consumer have in the past far outweighed the disadvantages. It is our belief that some lead will continue to be to the advantage of the consumer because auto emission standards for 1975 can be met.

CONCLUSIONS

For the past several months a number of oil companies and auto companies have issued statements concerning the compression ratios. Octane and lead content of gasoline that the public may expect beginning in 1971. Mobil Oil has refrained up until now from making any statement concerning this issue. We have done so because we wanted to systematically evaluate the results of joint research carried on under the auspices of the Inter-Industry Emission Control program. We also want to evaluate the results of our own research and that made public by other companies. Our evaluation has progressed to the point where we have reached this conclusion.

The problems of auto emission pollution should be considered in three categories:

1. Pollution caused by cars now on the road,
2. Potential pollution which may be caused by cars built between 1971 and 1974, and
3. Potential pollution of cars built after approximately 1974 but meeting Federal emission control standards.

In considering these three categories, we will attempt to set forth the steps which can immediately be taken to reduce pollution; steps which can be taken for the upcoming cars to minimize emissions: and steps which may be feasible to virtually eliminate pollution on cars with complete emission control devices.

1. *Existing Cars.*—Clearly, these will be the worst polluters, as new low-emission cars appear. Steps should be taken to abate existing car pollution.

2. *1971–1974 Models Cars.*—If the 1971–74 model cars will require a new low-octane grade of gasoline that is virtually lead-free (0.5 gram lead per gallon of fuel), we will provide it. These cars should be required to operate without any increase in hydrocarbon emissions, particularly aromatics.

3. *1975 Model Cars.*—If it develops that 1975 model cars will require totally lead-free gasoline to meet emission control targets, we will provide this also. But it is not yet known that zero-lead gasoline will actually be required for these cars. Time is available to complete the work necessary to determine this. We urge that this time be provided in the interests of the consumer who may bear the ultimate burden of a premature decision—in terms of potential engine damage and increased emissions with existing cars, and unnecessarily high costs with all cars.

In light of the foregoing comments, it is Mobil's position that the proposed amendments to the Clean Air Act contained in Section 5 of S. 3466, i.e., the granting of authority to the Secretary to establish standards respecting the composition or the chemical or physical properties of any fuel or fuel additive, is neither necessary nor wise at this time.

It is not necessary because the control should remain as established by the Air Quality Act of 1967; namely, control what comes out of the automobile, not what goes into it.

Thus, the concern over lead should be directed toward the level of emissions from the tailpipe, rather than toward regulating the lead content of gasoline. This is the approach that has been taken on gaseous emissions and it has resulted in good progress in meeting standards applicable to those emissions. We at Mobil feel confident that the Federal Government's emission control targets for 1975 model cars can be met at the least cost and inconvenience to the consumer without regulating fuel composition, if meeting these standards is left up to the ingenuity and innovation of industry.

As we have stated, we consider the proposed amendments unnecessary, but, in addition, in their present form they are unwise and potentially detrimental. We emphasize this point because they do not include provisions regulating the other components of the fuel-engine system. When Congress passed the Air Quality Act of 1967, it denied the Department of Health, Education and Welfare the authority to certify fuels or additives because it had not been established that it was necessary to do so. If such control is to be established at this time, it would be unwise not to include standards for the entire fuel-engine system. Only in this way can we be sure that the consumer will receive the maximum benefits of the very complex fuel-engine trade-offs.

MOBILE CORP.,
New York, N.Y., April 10, 1970.

Hon. ROBERT H. FINCH,
Secretary of Health, Education and Welfare,
Washington, D.C.

MY DEAR MR. SECRETARY: I am writing in response to your letter of March 20 concerning tetraethyl lead as a gasoline additive. My comments will be directed toward your desire "to ensure the greatest and most rapid reduction in air pollution at the lowest possible cost to the public." In this regard you may be interested that three years ago in a publication published by Mobil called "Primer on Air Pollution," we made the following statement: "If getting the lead out is going to be the most effective economical way to beat pollution—which no one knows—Mobil will get the lead out." Our research and analysis over the past three years would lead us to make the same statement today.

There are two areas which must be examined very carefully before a conclusion can be reached as to how auto emission pollution can be maximumly reduced at the least cost to the consumer. These are:

1. How many grades of fuel should be available to the motorists, and
2. How to balance the fuel needs of existing cars with those of new cars.

As to the first, i.e., how many different octanes should be made available. There appear to be two options—either a two grade system composed of a new 91 octane no-or-low lead fuel and a 97 or higher premium with today's lead content, or a three grade system with a new 91 octane no-or-low lead, and present regular and premium octanes at today's lead levels. To achieve a two grade system would require legislation precluding today's regular 94 octane leaded fuel; and, in addition, would either require existing cars to be derated so that they could run on the new 91 octane low lead fuel, or require the owners to pay the increased cost of using the 97 or higher octane premium grade. We question whether it would be feasible to mandate the elimination of the middle grade and whether it is economically advisable to either derate the major portion of the 100 million cars now on the road, or force their owners to pay for gas at an octane level beyond that which their car needs.

A three grade system, as described above, would allow existing cars to continue to operate without any economic penalty and would not require legislative controls as to the number of grades to be offered motorists.

As to the second area, i.e., the fuel needs of existing cars as compared to those which will be built in the future, I should like to state that it is our understanding that the desire for lead reduction stems from the auto companies' conclusion that lead shortens the life of the emission control devices they intend to put on 1974 cars. Before addressing myself to that point, I should like to point out that any new fuel system must consider the fuel needs of the 100 million cars presently on the road.

It is our conclusion after very careful consideration that the vast majority of these existing cars must run on a gasoline with lead and at today's octane levels. We reach this conclusion for two reasons: First, the compression ratio of these cars preclude their running on a lower octane fuel than they are currently consuming unless they were derated which we think is not a practical course of action. For the present some lead is needed to achieve that octane. Secondly, lead forms compounds during combustion which lubricate the exhaust valve in the engine. We understand from auto industry technicians that without this lubricant the valves wear or "pound-in" the valve seats causing the required perfect fit at the moment the engine is fired to become imperfect. As "pound-in" progresses, gasoline mileage and fuel losses result and eventually can lead to severe engine damage. This valve-wear problem was described by the Ford Motor Company in testimony presented to the Muskie Committee on March 25. In this testimony Ford said that "complete removal of TEL (anti-knock fuel) or complete reduction of TEL levels at 0.1 and 0.25 cc's per gallon would cause serious deterioration of engine's ability to function."

We would also point out that we really do not know what possible additional pollution might result from the operation of cars with unleaded gas and without emission control devices, particularly if octane increases were achieved through additional aromatics. We do know that aromatics do have some impact on smog and the Los Angeles Air Pollution Control Board has questioned the desirability of increased aromatics in unleaded gasoline.

The one positive aspect concerning existing cars is that over a period of time whatever pollution problem we have with them will continuously decrease and ultimately vanish as they are retired.

Cars produced in the future will provide the best opportunity for reduction of emission pollution at the lowest cost to the consumer. Therefore, the basic questions are whether the emission control systems operating with leaded fuel will prevent lead emissions from going into the air and operate for a reasonable period of time. If these two cannot be achieved, then the alternative would be to use totally unleaded gas. While it is true, as the auto companies have pointed out, that the advanced emission control system they envision introducing in 1974 will have a lesser life if present leaded fuel is used, it still may be better for the consumer to have a low leaded fuel and a catalyst that may have to be replaced after a period of time.

Our research to date indicates that catalytic emission control systems using present leaded fuels will operate for at least 14,000 miles, whereas those without lead will probably go as long as 50,000 miles, and it appears that with low lead gasoline the mileage utility will be somewhere between these ranges. The question is what system should be adopted which would be best for the consumer. In this regard, we would point out that E. N. Cole, President of General Motors, in a letter to us on March 31 said the following: "However, if a reduction in control system life would be acceptable to the regulatory agencies, a small amount of lead could remain in the fuel beyond 1975. Any position on this would seem to depend on a careful analysis of the trade-offs." An analysis of these trade-offs would have to weigh the added cost to the consumer of totally unleaded gasoline against possible earlier replacement of a catalyst because of lead contamination.

In summary, it is our view that the quickest way to achieve significantly reduced pollution and at the lowest cost to the consumer would be to have a low leaded octane fuel introduced at this time with the option to continue marketing current octanes with present lead content or, if feasible, with some reduction in lead. This would achieve the following:

1. It would enable new cars to be operated on a low lead fuel.
2. It would protect the efficient operation of existing cars, and
3. It would provide the opportunity to test emission control equipment which would be needed by 1974 and to determine whether it is in the consumer's interest to have them operate on a low leaded fuel.

These conclusions are based upon a careful review of a great deal of technical, economic and marketing data developed by Mobil staff personnel. We have tried to direct our conclusions toward goals of reducing pollution while protecting the economy from unnecessary construction inflationary pressures and the consumer from unnecessary increased expenditures.

I would be happy to make myself or any of my technical staff available for further discussion.

Sincerely,

RAWLEIGH WARNER, Jr.,
Chairman of the Board.

NATIONAL LP-GAS ASSOCIATION,
Chicago, Ill., March 16, 1970.

HON. EDWARD S. MUSKIE,
U.S. Senate,
Senate Office Building,
Washington, D.C.

DEAR SENATOR MUSKIE: We have noted the introduction and hearings on your Bill S–3546 relating to Standards for Air Quality. The members of the LP-gas industry can make a substantial contribution to minimizing air pollution in providing for the use of LP-gas as an engine fuel. We thought you would be interested in the enclosed brief summation of the contribution that LP-gas can make. If at any time it is desired, we can supply other materials, including test data and the consultation services of industry experts. We would welcome the opportunity of providing any additional information or assistance.

Respectfully yours,

ARTHUR C. KREUTZER.

LP-Gas Engine Fuel—Its Role in Air Pollution Abatement

Would a Change in A Vehicle's Diet Cure Air Pollution?

Distributed by
National LP-Gas Assn.
79 W. Monroe St.
Chicago, Ill. 60603

NLPGA

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Item: "Development of steam-powered buses will be studied in Dallas if Uncle Sam approves an application for a $464,684 grant."—Dallas Times-Herald, Jan. 7, 1969.

Item: "Bus riders in San Francisco will be riding buses powered by steam engines in 1970 under a demonstration program costing $610,000. . ."—Oil Daily, Feb. 18, 1969.

Item: "The California Highway Commission today appropriated funds to test the effectiveness of natural gas as a pollution-reducing propulsion system. . . The vehicles will be dual-fuel operated—with natural gas, or, beyond the range of the stored natural gas fuel, on gasoline."—From official news release dated March 20, 1969.

Item: In 1967, the Department of Health, Education, and Welfare supported a $75,000 study of electric vehicles conducted by the Arthur D. Little Co.

Item: "There is very little reason to think electric passenger vehicles will displace the internal combustion engine in the near future."—H. J. Young, Edison Electric Institute, in a talk before the International Automotive Engineering Congress, 1969.

Item: "Five oil companies joined Mobil and Ford Motor Co. in their Inter-Industry Emissions Control Program which, on a $7 million investment, proposes to develop a virtually emission-free gasoline-powered car within 2-1/2 years. . . They expect to reduce hydrocarbons to 65 ppm, carbon monoxide to 0.5%, nitrogen oxides to 175 ppm."—Power Magazine, February 1968.

Item: "A 1965 survey (on overall automotive exhaust emissions control). . . projected 1967 expenditures by the petroleum industry of $10 million. . . Industry was reported to have sponsored $2.26 million in air pollution research in non-industrial laboratories in 1966. . . Non-industrially supported projects (in atmospheric chemistry and the medical effects of pollutants) amounted to $16.5 million in 1966. . ."—The Automobile & Air Pollution: A Program for Progress, Part II, U. S. Dept. of Commerce, December 1967.

The Goal: A "Smog-Free" Car

The brief, occasionally paraphrased items on the facing page are random evidences of the seriousness of the smog problem in the United States, and of the time, effort, and money being invested in the search for a cure.

What is the goal? A "smog-free" car, which the California Air Resources Board has defined as one that gives less than 50 ppm hydrocarbons, 0.5% carbon monoxide, and 100 ppm nitrogen oxide after 50,000 miles.

All the efforts cited have two things in common:

1. None has yet proved practical, and
2. All have cost—or are costing or will cost—the taxpayers, whether they prove out or not.

In Contrast . . .

. . . there is one solution that already appears practical and has cost the taxpayers nothing in the proving. Its name: **propane.**

In one officially sanctioned test, using approved test equipment, under a program set up and supervised by the California Air Resources Board, a 327 cu. in. engine (converted from gasoline to propane) recorded the following results, projected to 50,000 miles:

	With Gasoline	With Propane
Hydrocarbons, ppm	195	30
Carbon monoxide, %	1.89	0.23

Using the two criteria that are now recognized (nitrogen dioxide is not presently covered), the vehicle qualified as a true "smog-free car"—**so long as it was fueled with propane.**

Smog-Free Car? Or No Smog-Fuel?

If such readings are obtainable with a standard engine, do we need a new **type** of engine? Or, as an alternative, must we continue to try to modify the internal combustion engine to compensate for the inherent smog-making properties of gasoline?

Maybe the internal combustion engine isn't dead. Maybe it doesn't even need a heart transplant. Maybe all it needs is a change of diet!

The diet of most vehicles today is gasoline. But gasoline is a combination of a number of ingredients—most of them hydrocarbons. A typical premium might contain 25% aromatic hydrocarbons, 17% olefins, 50% saturates (paraffins and naphthenes). A representative regular grade could contain 20% aromatics, 22% olefins, 50% saturates. (1)

All gasolines except white gas also contain tetraethyl lead. Tests have shown that gasolines containing tetraethyl lead (TEL) in concentrations of 0.5, 1.5, and 3.0 ml/gal. produced exhaust concentrations of hydrocarbons that were at least 150 ppm higher than those from unleaded gasolines after 18,000 miles in service. (2)

All hydrocarbon feedstocks produce some hydrocarbons in the exhaust. But each one is different in its capacity for making smog. As a class, olefins are the worst smog makers. Aromatics also produce smog, but to a lesser degree. Saturates make very little if any. (3)

The best diets among the hydrocarbon fuels then are natural gas (methane) and its close relative, propane, because both are paraffins.

Methane or Propane—Which?

Natural gas is a fine fuel, but difficult to transport except by pipeline. Unless you compress it or liquefy it, natural gas takes up too much storage space. A cube of it (in gas form) measuring about 5 × 5 × 5 ft. would have about the same energy as one gallon of gasoline.

It can be compressed but it would still be too bulky, the tanks to hold it heavy and expensive. It can be reduced to 1/600th its volume if it is liquefied, but the tanks are costly. You can't buy liquefied or compressed gas just anywhere.

Propane, though, is available everywhere—in every city, town, village, and hamlet. (No need to switch to gasoline when you get "beyond the range of the stored fuel.") It is proved, having been used in trucks, tractors, cars, fork lifts, and stationary engines for over 40 years. It has run locomotives and fueled airplanes.

And think of this: You can take a vehicle designed for gasoline and convert it to run on propane, and it will run better than it did before.

Why is propane the least of the smog

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1. Surgeon General's Report to the U.S. Congress, "Motor Vehicles, Air Pollution, and Health," June 1962.
2. Gagliardi, J. C., "Effects of Tetraethyl Lead Concentration on Exhaust Emissions in Customer Type Vehicle Operation," SAE Paper 690015, Jan. 13-19, 1969.
3. "Search," May/June 1966. Published by Technical Information Center, General Motors Research Laboratories.

Change of Diet . . . Take certain hydrocarbons, add nitric oxides, expose them to the sun, and what you'll have is smog.

makers? Why have engineers at Cities Service Oil Co. stated flatly, "Total emissions control is possible with an LP-gas vehicle"? (4)

Let's ask first: Just what is smog?

Smog . . . is it Smoke?

No, nor is it particulate matter either. It is not something you can see issuing from the tailpipe of an automobile. It is the product of certain reactions that take place between certain chemicals emitted from the automobile.

Photochemical smog is so named (5) because its objectionable characteristics are due not to the mere emission of substances to the atmosphere but rather to the products formed by the chemical reactions of these substances in the atmosphere. These reactions occur only when radiant energy is supplied by the sun; hence the name photochemical smog.

The principal substances are hydrocarbons from exhaust gases and evaporation losses, and nitric oxides from the exhaust.

When hydrocarbons and nitric oxides meet, they combine and recombine in a chain of 13 reactions. Somewhere in the middle of the chain, smog is formed. But before the 13th reaction has taken place, the formation of smog stopped.

Why is it stopped? Because nitrogen dioxide, which is formed in the first reaction, is "two-faced." In reaction No. 2, it absorbs sunlight and triggers the formation of smog; in reaction No. 11 it reacts with oxyalkyl radicals to form an alkylnitrate, which stops the chain—is, in effect, a dead end.

Thus nitrogen dioxide both starts and stops smog formation.

How then can you eliminate smog? **Eliminate the hydrocarbons.** Does it help to eliminate the oxides of nitrogen as well? This is a matter of some contention. One authority says that, unless you eliminate practically all of it, merely reducing it will actually increase the rate of smog formation. "It is clear that a combined reduction in both hydrocarbons and nitric oxides decreases the smog formation less than hydrocarbons reduction alone." (5)

So the role of nitric oxides might be a bit difficult to define. But the role of hydrocarbons is clear. They are the real culprits. (That is, some of them are.)

There Oughta Be a Law!

. . . and there is—or rather are.

Control legislation was born in the Los Angeles area, because that's where smog had its start (at least in the U. S.) Then California became involved, and the federal government followed, and now the states are coming into the picture, one by one.

They have had to attack the problem in segments, for there are four general sources of pollution emissions. The crankcase breather pipe is one source. A second is the carburetor, from which fumes evaporate. A third is the fuel tank, also a source of evaporation. Fourth is the tailpipe.

Legislators started with the crankcase emissions, because they were the easiest to control. Equipment that would recirculate the blowby vapors was made mandatory. This step was an important one, for it is estimated that this source originally contributed about 20% to total hydrocarbon emissions. (6)

Then, in 1966, California's legislature took out after the tailpipe, which was—and is—the No. 1 offender. All of the carbon monoxide and about 63% of the hydrocarbons come from this source, according to HEW. (6) California set a limit of 275 parts per million on hydrocarbons, 1.5% on carbon monoxide.

In 1968, the state moved to tighten up the restrictions, and the federal government quickly followed suit. They both also changed the yardsticks from parts per million to grams per mile—that is, from concentrations to volumes. The reason is that actual volume is a fairer standard, and would have been used sooner had adequate instrumentation been available.

The Squeeze Is On

Yearly, these restrictions will grow progressively tighter. For the 1970 model year, California has placed a limit of 2.2

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4. Baxter, M. C., "Total Emissions Control Possible With LP-Gas Vehicle," SAE Paper 680529, Aug. 12-15, 1968.

5. Caplan, John D., "Smog Chemistry Points the Way to Rational Vehicle Emission Control," SAE Paper 650641, Aug. 16-19, 1965.

6. HEW release U-21, June 4, 1968

All propane vehicles tested were well within the limits of the law—some amazingly so.

grams/mile of hydrocarbons, 23 grams of carbon monoxide; in 1971 a limit of 4.0 grams/mile will be imposed on oxides of nitrogen. In 1973, the limits will be 1.5 grams/mile of hydrocarbons, 23 grams of CO, 3.0 grams of oxides of nitrogen. In 1974, oxides must be reduced to 1.5 grams/mile.

In 1970, vehicles over 6000 lbs. will have to meet the 275 ppm, 1.5% CO standard; in 1972, it will drop to 180 ppm and 1.0% CO.

For 1970 models, the federal government has the same rules on carbon monoxide and hydrocarbons as California. "The new standards," said Wilbur Cohen, then secretary of Health, Education, and Welfare, "will reduce the tailpipe emissions of carbon monoxide and hydrocarbons by about 30% below the limits. . . in effect for the 1968/1969 model years." (7)

Tough Laws! Can Manufacturers Meet Them?

Each year, the automobile manufacturers rework their engines and combustion systems in an effort to further reduce harmful emissions below the previous year's readings. So far they have been successful, though not spectacularly so. (Unfortunately, sometimes this tinkering adversely affects the engine's smoothness and performance.)

In the certification tests for 1969 model automobiles, General Motors Corp. tested 75 engines of various sizes. Of these, 48 had corrected readings of more than 200 ppm. Half of Ford's 46 engines were over 200, as were 14 of Chrysler's 24. (7)

How About Propane Vehicles? Can They?

There have been a number of tests made using propane in converted gasoline engines. Some were new engines, some not so new. But in almost every instance, propane did better than gasoline.

The following tests were conducted at various times by official testing stations for Petrolane, Inc., a leading LP-gas marketer; for Western Liquid Gas Association; and for two carburetor manufacturers, Impco and Marvel-Schebler.

CID	trans. type	Gasoline		Propane	
		Hc	CO	Hc	CO
292	manual			56	0.18
302	manual			170	1.49
225	automatic			170	0.41
383	manual	393	1.06	219	0.89
240	automatic	356	1.68	230	0.31
327	manual	195	1.89	30	0.23
390	automatic	230	2.37	36	0.36
351	automatic	na	na	168	0.68
250	manual	256	na	99	0.31
350	na	148	1.37	150	0.0
383	automatic	187	0.79	240	0.79

Because of the widely varying conditions of the engines, and the variances in conversion techniques, results covered a broad range. However, all vehicles qualified under the law. And, in these 11 tests, only three were over 200 ppm. Four were under 100. Only one registered CO reading of more than 1.0. One registered zero.

Gasoline Will Get Worse

Those tests don't make propane look like a miracle fuel, do they? Just much, much better than gasoline—at least in most of the tests.

But the raw figures hardly begin to tell the story. They don't reveal that, when a system is certificated by the auto manufacturer, the engine is brand new and in fine tune for an optimum run on gasoline. The vehicles that were run on propane however, were not new. Some had 8000 to 10,000 miles on them. One had more than 19,000.

But what happens to a gasoline engine when it begins to accumulate miles? It deteriorates; even at 4000 miles it won't produce as good a reading as when it was new.

Since the start of the 1966 model year, the California Air Resources Board has conducted continuing surveillance tests. As of the end of the year 1968, spot checks had been made on 3032 cars—1119 1966 models, 1302 1967 models, 611 1968 models.

The board found that at 4000 miles the average 1966 model was emitting 264 ppm hydrocarbons, 1.27% carbon monoxide; the 1967 car, 264 and 1.15%; the 1968 car, 244 and 0.90. By 15,000 miles, the average 1966 was emitting 335 ppm, 1.54 CO; the 1967, 304 and 1.42; the 1968, 277 and 1.06.

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7. Ibid

*Change of Diet . . .
Gasoline-fueled vehicles deteriorate much faster than those fueled with propane*

These tests were made at "hot start." Concluded ARB: "If 250 ppm of hydrocarbon on a hot start basis is assumed equivalent to 275 on a cold start basis. . . both the 1966 and 1967 models are over the standard at 4000 miles, and the 1968 models cross the 250 ppm at 8000 miles." The 1966 cars crossed the CO "line" at 6000 miles, the 1967 at 15,000, the 1968 not at all.

Why Does It Deteriorate?

Obviously the gasoline-fueled engine begins to deteriorate early. Why? "The formation of combustion chamber deposits appears to be a major factor accounting for the increase in hydrocarbon emission levels," say two researchers at Du Pont. (8) Also, they found, "Hydrocarbon exhaust emission levels of cars operated on gasoline containing tetraetheyl lead are usually higher than those of cars operated on unleaded gasoline."

Other research engineers found (9) that tetraethyl lead (TEL) increased hydrocarbon levels at least 150 ppm after 18,000 miles of operation. Ring wear was increased and blowby rates were also increased by the use of gasolines that were heavy in TEL.

Will A Propane-Fueled Engine Deteriorate?

It's bound to—a little. But the rate of deterioration is very small. In a program set up in California to establish the acceptance criteria for conversions of vehicles to propane, the Air Resources Board assigned propane-fueled engines a 1.12 deterioration factor. Thus a car that had been tested for 4000 miles on propane, and found to have emitted 100 ppm., would be expected to emit 1.12 times that much (or 112 ppm) at 50,000 miles.

Why does it deteriorate more slowly than one fueled by gasoline? Because propane does not deposit carbon in the combustion chamber. Nor does it contain TEL.

The Other Sources Of Smog . . .

As was mentioned before, emissions come from more than one source. First there was the crankcase breather pipe, from which issued unburned contaminants which had been washed down from the combustion chamber. This source contributed 20% of the pollutants.

Second was the tailpipe, which accounted for 63 to 65% (10) of all automotive pollutants.

Third and fourth are the fuel tank and the carburetor, from which gasoline evaporates. (Note that gasoline does not have to be burned to make smog; it will make it just sitting there doing nothing!) Evaporation produces 15% of the smog-making pollutants.

. . . Could Be Cut Out With Propane

With no wall washdown, and very light carbon deposits, there is no leakage of unburned hydrocarbons into the crankcase.

Propane cannot evaporate; it is held in a pressure container, tightly sealed, and the fuel system is closed.

So with propane, 20% of the problem (crankcase emissions) and 15% (evaporation) would have already been eliminated.

Now, back to the other 65%—the tailpipe emissions: We have already seen that propane can reduce hydrocarbons by at least a third, often more. If they were reduced but one-third, we would find that the smog equation with propane now reads:

100% air pollution-20%-15%-1/3-(65%)=43%

But this is not the whole story. There are hydrocarbons—and hydrocarbons. Some make lots of smog, some little. Some are 100 times as bad as others!

The bad actors and the relatively inert ones will be identified and their roles defined in next month's concluding installment, which will also endeavor to measure propane's potential in the fight against air pollution.

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8. Pahnke, A. J., and Conte, J. F. "Effect of Combustion Chamber Deposits and Driving Conditions on Vehicle Exhaust Emissions," SAE paper 690017, Jan. 13-17, 1969.
9. Gagliardi, J. C., and Ghannam, F. E. "Effects of Tetraethyl Lead Concentrations on Exhaust Emmissions in Customer Type Vehicle Operation." SAE paper 690015, Jan. 13-17, 1969.
10. Swartz, D. J., Wilson, K. W., and King, W. J., "Merits of Liquefied Petroleum Gas Fuel for Automotive Air Pollution Abatement," Report No. 61-35 of the Department of Engineering, UCLA, August 1961.

II. Reactivity Is The Real Issue

There are hydrocarbons—and hydrocarbons. When it comes to making smog, some are bad, some are innocent, some are in-between.

Hydrocarbons are compounds containing hydrogen and carbon. There are many kinds—in fact, a typical exhaust sample from a gasoline-fueled engine contains from 100 to 150 different ones. (2) Some have very simple formulae (such as methane, CH_4; propane, C_3H_8, or butane, C_4H_{10}). Some have unpronounceable polysyllabic names and very complex formulae.

Smog, as we have learned (5), is formed by the **reaction** of hydrocarbons with nitric oxide in the presence of sunlight. But not all hydrocarbons are really reactive. For example, methane, ethane, butane and propane are hardly reactive at all. Some others are 100 times as reactive as these four.

Their reactivity varies with their makeup and their makeup depends upon the relative numbers of atoms of each element and their arrangement into molecules. Some are saturates, for example, others unsaturates. They all fall into general classifications such as paraffins, aromatics, olefins, and naphthenes. Gasolines contain compounds from all these classifications.

Propane and butane are paraffins. They are also saturates. Paraffins have very low reactivity.

This is the second and concluding installment in this review of the potential role of LP-gas in air pollution abatement. Purposely technical in nature, it is presented in the hope that marketers will use it to educate air pollution control officials on the advantages of the fuel.

Aromatics occupy a middle ground.

As a group, olefin compounds have very high reactivities, and therefore give greater smog severity for a given concentration. (2)

But this is oversimplification. If olefins are bad, some are only mildly so. The really bad ones are about 20 times as reactive as the mildly bad ones. (2)

These variances in reactivity have caused some experts to characterize the law limiting automobile exhaust emissions of total hydrocarbons to 275 parts per million as a "sledgehammer approach, since it assumes that all hydrocarbons are equally reactive in the formation of smog."

It's Speed That Counts

The research we have referred to measured reactivity by the speed of the reaction. Propane, combined with nitric acid in sunlight, produced less than 0.5 parts per billion per minute. Some of the less reactive olefins produced from 1.5 to 3.5. The truly reactive ones yielded 30 to 60 parts per billion!

Overall, it has been found that olefins can be responsible for 75% of the reactivity in an exhaust mixture. A 50% reduction in total hydrocarbons may conceivably give as little as 5% reduction in smog—or as much as 95%—depending upon which specific hydrocarbons are reduced. (2)

We have seen that a typical premium gasoline might contain 25% aromatics, 17% olefins; a regular grade 20% aromatics, 22% olefins.

What does commercial propane contain? At least 90% pure propane, a saturate.

But What Happens When It Burns?

Does what goes into an engine determine what comes out the tailpipe? If propane is non-reactive, is the emission from the tailpipe of a propane-fueled vehicle equally clean?

The engine **does** do things to the fuel. An internal combustion engine acts like a thermal cracking plant, and, as a result of incomplete burning, will cause a

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2. A reactivity chart shows that the nitric oxide photo-oxidation rate in parts per billion per minute is approximately 0.4 for propane and approximately 35 to 60 for disubstituted olefins. In between lie such compounds as terminal olefins, ranging from about 1.5 to 3.5; diolefins, approximately 3.5 to 4, mono-substituted internal olefins, from about 9 to 18, etc.

Change of Diet . . . Even the other 26% of hydrocarbons in propane exhaust burn milder.

change in the structure of the fuel passing through it. (10)

But a high percentage of what comes out of the exhaust is still propane (or butane, if this type of LP-gas is used). (10) Butane produces from 37 to 74% normal butane in the exhaust hydrocarbons, propane from 52 to 74% propane. (1)

But how about the other 26%?

They Burn Milder

The 26% of hydrocarbons that are something other than propane include some aromatics and some olefins. In fact, there are a fair number of olefins in propane exhaust. But the exhaust olefins are predominantly two- and three-carbon mono-olefins, with only trace quantities of di-olefins. No aromatics or olefins heavier than four-carbon atoms are produced by LP-gas fuels (butane and propane). (1)

These olefins, then, are mildly reactive compared to the highly reactive ones. These latter have been termed "higher olefins," and in a test conducted several years ago at UCLA (10), gasoline exhaust was found to contain 25 to 120 parts per million of them. Propane exhaust contained none. In total olefins, gasoline exhaust carried between 315 and 580, propane between 191 and 377.

On the basis of these tests, UCLA concluded that, "If we equate total olefin content with potential for eye irritant formation, we see that LPG exhaust contains at most two-thirds of the olefin concentration that is found in gasoline exhaust."

The statement is highly conservative and reflects the caution of the professional research man. Actually, the olefins in the propane exhaust included only ethylene, propylene, and 1-butenes. All of these are only mildly reactive. The worst, propylene, has a reactivity of only 10 on a scale that goes as high as 100. (5) **Propane, where have you been all this time?**

Long Ago, LPG Was Recommended

In the early 1950s, scientists recommended that propane be used in the buses and local fleets in the Los Angeles Basin, but their advice went largely unheeded.

It wasn't until the mad scramble for exotic answers, such as liquefied natural gas, compressed natural gas, electric and steam cars, reached its peak that the LP-gas industry decided to study the potential seriously.

Studies proving propane's anti-smog capabilities had been broadening year by year. For example, McReynolds and others (11) found that "the gaseous hydrocarbons, propane and butane, yielded substantially less hydrocarbons than the heavier fuels studied. . . which, in turn, were markedly less photochemically reactive than exhaust from the gasoline boiling range. . . In cases where exhaust reactivity was high, the original fuel was more reactive." And theirs was only one of many studies that carried similar conclusions.

But under the law, reactivity has had no standing. In writing of "Motor Vehicle Standards, Present and Future" (12), Maga and Kinosian explained the reasons why in these words:

"It was known at the time emission standards were first established in California in 1959 that organic compounds differ widely in their reactivity in the hydrocarbon-oxides of nitrogen-sunlight system. Olefins were believed to be primarily responsible for the formation of eye irritants, phytotoxicants, and aerosols, while most organic compounds, **except the light paraffins,** were believed to be responsible in varying degree for ozone formation.

"It was also recognized that the hexane-sensitized nondispersive infrared instrument (NDIR) had a poor response to olefins and to aromatic hydrocarbons. . . By reducing the paraffins more than the olefins and aromatics, a control device conceivably could meet the hydrocarbon standards without causing as much of a reduction in the smog-forming potential of the exhaust gases as would be indicated by the NDIR. Conversely, by selec-

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11. McReynolds, L. A., Alquist, H. E., Wimmer, D. B., "Hydrocarbon Emissions and Reactivity as Functions of Fuel and Engine Variables." SAE Paper 650525, May 17-21, 1965.
12. SAE Paper 660104, Jan. 10-14, 1966.

Change of Diet

What if we had an engine that was actually designed for LP-gas?

tive reduction of the olefins and some aromatic hydrocarbons, a control device could cause a large reduction of the smog potential of the exhaust gases and yet fail to meet the standards."

Test Equipment Is Found Wanting

So the official test equipment can't really tell just how good propane is. Or how bad other fuels are. Nevertheless, we must live with it until it is replaced by something better. Other testing equipment that will read higher olefins but not some of the harmless hydrocarbons is now available. But it has no official standing.

So for now the LP-gas industry can only work at reducing **all** hydrocarbon emissions toward the vanishing point. We must do it using gasoline test equipment and gasoline standards.

But Suppose We Started Anew . . .

Suppose we should start out anew with an engine designed for propane—designed to cut smog to the lowest possible figure. What might be the results in terms of emissions?

For a clue, check the findings of Lee and Wimmer of Phillips Petroleum Co. (13). Here, in their own words, is what they did, and why:

"Differences in the power-producing capacities and exhaust emission characteristics of various spark-ignition-engine fuels are frequently obscured by interactions involving the particular engine system used in the comparison. In an attempt to minimize this problem, gasoline, propane, (and other fuels) were compared in a single-cylinder engine **under conditions that were optimum for each fuel.** (Emphasis supplied.)

They found that "propane compared with gasoline . . . reduced engine power capacity by 6% (but) reduced carbon monoxide emission by 99+%, reduced polluting exhaust hydrocarbon emission by 87%, reduced nitric oxide emission by 53%. . . ."

Let's Be Practical

Just how much of the motor fuel market can propane really serve? In the Los Angeles basin alone, which has more vehicles than entire states, it has been estimated that consumption of gasoline in 1968 was in excess of 3 billion gals. a year. This represents almost as much "energy" as 4 billion gals of propane.

This is equal to about 22% of all the LP-gases produced in the United States in 1967 and some 42% of all the propane produced. It would hardly be practical to divert all that propane to this single market.

However, by using it in fleets of trucks, delivery vehicles, and buses, these sources of smog would be sources no more, so this would be a good start. All city vehicles could be operated on propane—not only in Los Angeles, but in any big, smog-ridden city.

And much, much more LP-gas can be produced. At present some 25% of it is made as a co-product in the refining of gasoline, and the percentage recovered can be stepped up materially. How far refineries can go in "tooling up" for greater propane production is strictly a question of economics.

The other 75% comes from "wet" natural gas and is stripped out of the gas as it comes from the earth. The products are termed "natural gas liquids," and they are chiefly propane and butane together with some natural gasoline.

As of the end of 1967, the total reserves of crude oil in the United States were reliably estimated to be 31.4 billion barrels, the total reserves of natural gas liquids 8.6 billion. (14) In other words, there was only slightly more than 3-1/2 times as much crude oil in the ground as gas liquids. It is obvious that production could be stepped up very materially—spectacularly, as a matter of fact. But it might take a little while.

On a selective basis, propane can go a long way toward curing our smog. It's here today, and proved—and an excellent network of more than 15,000 dealers across the United States provides a very fine nucleus for distribution. ■

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13. Lee, R. C., and Wimmer, D. B., "Exhaust Emission Abatement by Fuel Variations to Produce Lean Combustion," SAE Paper 680769, Oct. 29-31, 1968.

14 See Butane Propane News, May 1969, p. 64.

STATEMENT OF WILLIAM S. JONES PRESIDENT, NATIONAL OIL JOBBERS COUNCIL

Mr. Chairman, Members of the Subcommittee, I would like to thank you for allowing me to present this statement on behalf of the 10,000 independent petroleum marketers represented by the National Oil Jobbers Council. As a group, they dispense approximately one-third of the automotive gasoline consumed in the United States.

The National Oil Jobbers Council fully supports all reasonable efforts to prevent or eliminate pollution of any aspect of America's environment.

It is reassuring, Mr. Chairman, to see you and your colleagues expending so much time and thought toward the very important goal of restoring the Nation's environment. Certainly, removing pollution from the air we breathe is a task worthy of your efforts, and, indeed, one central to our ctitizen's continuing existence.

The Nation's independent petroleum marketers, for whom I appear as spokesman today, fully support your efforts in this respect and fully share your concern that the job be done promptly and well.

There are, however, several caveats that we wish, in all earnestness, to inject into your deliberations. We are fearful of the pressure tactics being used by certain sectors of industry with respect to this problem. We are fearful, too, of the apparent tendency toward overreaction which has resulted in what has been termed by some observers as hysteria. By this, I do not mean to intimate that action should not be taken or that it should not be taken as promptly as your judgment requires. What does disturb me is this: The giants of Detroit have been given emission standards with which they must comply. These are performance standards, which, of course, are always vastly preferable to so-called design or specification standards. Detroit has said that they cannot meet these requirements unless lead is removed from gasoline, although this latter statement has been somewhat tempered by an indication that the reduction to a half gram of lead (rather than its complete elimination) would be sufficient.

Faced with this situation, the Executve Branch of government has ridden off in all directions. The Department of Commerce has designated a Technical Advisory Board to study the question. These proceedings are closed. The transcript, and for that matter, the list of the witnesses, is not available.

The Department of Health, Education and Welfare has distributed a questionnaire seeking the views of the automotive and gasoline industries as to the desirability of lead removal and suggested manners of implementing that removal. It is not clear to what degree this information will ultimately be made public. What is clear, however, is that there is no orderly procedure being utilized; no opportunity for colloquy, let alone cross examination; no opportunity for rebuttal; no criteria for the relative weight to be accorded opposing points of view.

Against this background, the Administration's bill proposes, in essence, that the Executive Branch be given authority to write regulations to determine the ingredients of automotive gasoline. This is, of course, an abandonment of the performance standard approach of the Air Quality Act of 1967, which set standards for the emission from automobiles but left industry free to develop new approaches. The complementary forces of innovation and competition were left unfettered to work for the public interest.

Frankly, not being technicians, we do not know who is right. We are told that lead is a health threat, that emissions cannot be reduced to the extent required if lead is present. We are also told by technicians with equally impressive credentials that the elimination of lead would require the addition of aromatics, which would result in carcinogens being emitted—apparently, an even more serious threat to health than present emissions.

We do know this, however, that the average jobber is very small compared with the average refiner or automotive manufacturer. He owns 5.5 retail stations and is economically a rather fragile creature compared to the giants of either Houston or Detroit. If wrong decisions are made, if undue haste is implemented, if unnecessary expenditures are required, the impact upon the jobber will inflict far greater damage than that suffered by the infinitely large concentration of capital represented by refiners and automobile manufacturers.

In addition to all the other difficult factors present in this situation, it is rapidly becoming apparent that at least some refiners are using the unleaded controversy as camouflage to enter into the marketing of a third grade of gasoline. It is their right to market one, three or thirty grades of gasoline, or for that matter, to market in any other manner not inconsistent with the law, which will work to their advantage in the marketplace. It is, however, unfortunate that they have chosen this particular occasion as a cover for their actions.

It is our hope that you can find a way to get the job done with only one kind of regular gasoline. Our personal preference is for that containing a half gram of lead per gallon until 1975; thereafter, unleaded. The principal point to be made here is that if we are required to put in a third pump, it will cost the jobbers of America who own approximately 53,000 service stations on the order of a quarter of a billion dollars to effect this conversion. Further, the pump manufacturing industry indicates that the probabilities are that they could not manufacture pumps quickly enough to supply the need if a third pump were required within a relatively short period of time. Needless to say, without special provision being made for their equitable participation in pump procurement, independent marketers would not fare well in competing for pumps as against the major refiners who are far and away more influential customers of the pump industry.

It is our belief that by requiring that all automotive gasoline under 97 Research Octane Numbers be uniform as to lead content, the public would be best protected and the economic consequences—particularly to small business—would be minimized.

We have requested the American Petroleum Institute to sponsor a voluntary industrial standard specifying a half gram of lead per gallon and setting standards for other emission producing ingredients. This standard could be processed and promulgated by the National Bureau of Standards. As part of this process, the Antitrust Division of the Department of Justice would receive the opportunity to comment on the proposal. An adverse comment would, I am informed, preclude promulgation of the standard.

I do not anticipate any antitrust protest being made, even if it were, it seems to me that my proposal has two marked advantages. First, it would allow a voluntary solution to this important problem. Secondly, it would provide a way for industry to work together without being exposed to a possible antitrust violation, since the voluntary standard would never be promulgated or come into being should objection be interposed by the Department of Justice.

The White House scientific advisors have taken a somewhat sanguine view of most of the difficulties involved in this situation. Our industry's trade press recently carried a story in which one White House advisor indicated that to adjust one of today's high-compression automobiles to a diet of 91 octane unleaded gasoline, it simply involved a simple twist of the wrist via a screw driver which would be smilingly supplied without charge by your friendly neighborhood service station. While I cannot vouch for the correctness of this story, I would have to say that if it even approaches accuracy then it is errant nonsense. As an example, *Oil Daily* recently carried a story to the effect that:

"Authoritative automotive engineers and expert auto repair technicians checked by The Oil Daily over past weeks were in general agreement that the cost of adapting a high compression automobile engine to handle a 97 octane gasoline (which would be the highest rating the ARB-recommended program would permit) could be anywhere between $50 and $300—and that even then there'd be no assurance that the vehicle's performance would not be seriously impaired. De-tuning would also, of course, increase the car's gasoline consumption."

At the outset, I stated that NOJC and the inidividual jobbers belonging to our member associations in the several states fully support all reasonable efforts to eliminate pollution of any aspect of our environment.

We, of course, do not manufacture the gasoline. Nor, to my knowledge, are any of our members fortunate enough to own an automobile factory. So, in a sense, we are captives. We market the product available to us which is utilized by the motorist in the engines available to him. Nonetheless, we are being asked, collectively with the refiners and automotive manufacturers, to absorb the entire social cost of any changes in manufacture and distribution required to reduce those pollutants in the air resulting from automotive emissions.

Putting in a third pump will not increase our volume.

Putting in a third pump will not increase our profit.

Unleaded gasoline will inevitably result in a higher price to the consumer, (6¢ a gallon more if the practice of one major marketer already offering unleaded proves typical), both as a user of automotive gasoline and in a myriad of ways not yet fully discernible. An example of this latter is if, as many suppose, one of the methods used in the transition to unleaded gasoline is the increased use of aromatics, industry experts estimate that the price of these aromatics which are vital to the petrochemical industry will rise substantially. This increase will be reflected in the cost of the petrochemical industry's products.

Since the oil jobber is being singled out in the typical American town as the only local citizen being asked to pay a part of the price for any transition needed to clean up the atmosphere, it seems to us that he has the right to ask that consideration be given to the problems thereby created for him.

We feel that consideration should be given to finding a way to utilize the considerable research which has already taken place under such programs as the Inter-industry Emission Control program. It would be our hope that no action be taken toward a system which would be less than fully adequate, resulting not in the optimum job in cleaning up the air, but in the long run, resulting in additional costs to both the industries and the consumer when a second transition to a more adequate system became necessary.

In closing, I would like to comment on your willingness to study and consider this vastly complex problem. The Nation's independent petroleum marketers are confident that you will consider the total public interest including the difficult straits potentially confronting small businessmen if the effect upon them is not considered as part of the total problem.

SUN OIL CO.,
Philadelphia, Pa., April 9, 1970.

HON. ROBERT H. FINCH,
Secretary of Health, Education, and Welfare,
Washington, D.C.

DEAR MR. FINCH: In your letter of March 20, you requested our views on the problems and timing of removing lead from motor fuel and on the numbers and types of fuel to be marketed. In this letter I am replying to both your letter to me and that to Mr. Paul E. Taliaferro, formerly Chairman of the Board of Sunray DX Oil Company, now merged with the Sun Oil Company.

At the outset, I would like to make our basic position completely clear. The internal combustion engine is important to us, and we believe that no substitute that serves the public's needs as satisfactorily will emerge for many years. So we welcome, and in fact anxiously await, the production of automobiles equipped with advanced emission control devices. If the most effective devices require unleaded fuels, we stand ready to produce such fuels. We are not, in other words, opposed to the removal of lead.

We recognize also that the automobile emission problem involves not only a physical interaction between engines and fuels; it involves, in addition, an economic interaction that encompasses the interests of the consumer. It is thus a problem that calls for Federal leadership, and we have been in the forefront of companies in the petroleum industry urging Federal leadership in this area.

For reasons which will be given and illustrated, however, we take exception to the legislative action that is currently contemplated. It is our belief that the role of the Federal Government is to establish acceptable limits—to delineate and enforce limitations on emissions, and to express the public interest through guidelines for action leading to optimum results. This approach is one that encourages inventiveness and the best of competitive effort.

Federal leadership should not, in our opinion, consist of legislating the number and grade of fuels to be marketed, the compression ratios of engines, or other details of possible approaches to cleaner engine exhaust. To follow this approach is to guarantee that solutions more constructive than the ones legislated—more effective, more economical to the public—will not be found.

We continue to advocate and would welcome, initiative by the Federal Government in support of three-cornered working discussions among interested governmental agencies and the automobile and petroleum industries. We are confident that with known emission limitations established by you, and with a free exchange under government aegis of all available facts, an economic approach to the desired result will be forthcoming.

To turn now to the specific outlines of your letter, if Federal regulatory action is taken regarding lead content and grades of fuel we feel strongly that it should be structured so as to encourage maximum freedom of initiative in finding better answers. We assume that the basic intent of your three-point proposal is to minimize lead usage during an interim period and eliminate it entirely as soon as possible. We interpret the implied objectives of the three points to be as follows:

1. *An objective of providing "low" lead fuel as soon as a significant number of vehicles are in a position to use it.* While we have no objections to this step, we know of no evidence indicating that the introduction of "low" lead fuels in the absence of advanced emission control devices will substantially reduce exhaust emissions.
2. *An objective of providing unleaded fuel as soon as vehicles equipped with advanced emission control devices are available.* The proposed timing of this step, July 1, 1974, seems reasonable to us. Although the refinery construction industry will undoubtedly be greatly strained to build the necessary plants, it probably can be done. You might find it desirable to contact the engineering and construction industry to assess its capability in this regard.
3. *An objective of meeting fueling needs of high octane requirement vehicles remaining on the roads.*

Our fundamental objection to the course of action suggested in your letter to meet these objectives is that it would strait jacket innovation. It would arbitrarily outlaw, for example, many individual steps which might even accelerate the decline in total lead consumption by motorists. Specifically, it would prevent three-grade and multigrade fuel marketers from offering intermediate fuels of dimished lead content, and thus force the owners of all cars unable to operate on an unleaded low-octane fuel to jump to highly leaded premiums, consequently adding to the consumption of lead as well as to automobile operating expenses.

Consider one of a number of possible systems of three fuels (which would be ruled out by your proposal) in contrast with a two-fuel system such as you described:

Octane	2-fuel system		3-fuel system	
	Percent cars requiring [1]	Probable lead content [2]	Percent cars requiring [1]	Probable lead content [2]
91	51	0.5	51	0.5
94			25	.8
100	49	3.8	24	3.8
(3)	(3)	2.12		1.37

[1] Based on Ethyl Corp., Estimated Research Octane Requirements 1969, Light Knock.
[2] Based on estimated 89 RON unleaded national average pool production capability.
[3] Overall average lead content, g.

The above three-fuel approach, which is only illustrative, would permit almost a one-third reduction in total lead usage compared with the two-grade proposal. With increasing numbers of low-octane requirement vehicles appearing over time, the availability of choice within the lower octane range would grow in importance, both from the standpoint of the consumer's interest in economy and from the standpoint of total particulate emissions.

Sun Oil Company's marketing system employing a multigrade blending pump was designed with the objective of maximum octane choice at minimum cost to the consumer. In turning our attention to directing this system toward the objective of minimizing lead consumption, we find that the blending concept offers an even greater reduction in lead usage than the three-fuel example described above, but would be arbitrarily ruled out under your proposed mode of regulation!

We would suggest as alternatives to your proposal any one of several approaches:

1. Regulations could be adopted to insure the availability of a low lead level fuel, whatever else refiners might offer to satisfy the octane requirements of older cars. For example, after July 1, 1971, refiners could be required to supply a fuel of at least 90 octane containing no more than 0.5 grams of lead per gallon. Any other fuels would be subject to the current 4 grams per gallon limit. After July 1, 1974, a lead-free fuel of at least 90 octane would be required with other fuels remaining as at present but in reduced quantity. Finally, when most of the current car population if off the roads, lead could be eliminated entirely.

2. A flexible sliding scale of allowable lead as a function of octane number could be established which would give fuel marketers some options for action.

This scale would be reduced in one or more steps with time as required by the installation of emission control devices and the disappearance of the current car population.

3. Another approach could be the use of an averaging concept in which refiners would be permitted an average lead usage per total gallon of fuel produced, again declining over time to zero. With this approach the competitive pressures to develop innovative marketing systems would be maximized.

In closing, I would like to reiterate our position so that we are not misunderstood. We are not advocating the continued use of lead or opposing its elimination from motor fuel. We are advocating the development of Federal guidlines which will permit and encourage the maximum degree of innovation to achieve your objectives. We welcome the introduction of advanced emission control devices by the automotive industry at the earliest possible date and will provide the necessary unleaded, lower octane fuels when these can be used advantageously to achieve the benefits of such control systems. The public interest and our own self-interest are both served by the most rapid and economic solution to the problem of automotive exhaust emissions.

Sincerely yours,

ROBERT G. DUNLOP.

TEXACO INC.,
Washington, D.C., April 21, 1970.

HON. EDMUND S. MUSKIE,
Chairman, Subcommittee on Air and Water Pollution, Committee on Public Works, U.S. Senate, Washington, D.C.

DEAR SENATOR MUSKIE: On behalf of Texaco Inc., I should like to comment briefly upon bills S. 3229 and S. 3466, which were the subjects of hearings recently held before your Subcommittee on Air and Water Pollution of the Committee on Public Works.

Texaco is dedicated to the attainment and preservation of a high quality in the nation's air, water, and other environmental resources. Our Company strives to minimize the emission of air and water pollutants both in its petroleum operations and in the use of its products. Automotive emissions have been of great concern to Texaco, and it has carried out and is currently supporting extensive research programs to reduce such emissions.

Turning to S. 3229, "The Air Quality Improvement Act," Section 210, "Registration of Fuel Additives," the language of this proposed section is identical with that used in Section 210 of the amendments authorized by Congress in 1967 for the Clean Air Act. We endorse this provision and urge that this language be retained.

In 1969, Texaco and other petroleum companies working through the American Petroleum Institute aided the National Air Pollution Administration in determining the scope and extent of fuel additive use. To date, the Secretary of the Department of Health, Education, and Welfare has not designated any fuel or additive for registration, but Texaco stands ready to cooperate fully with the Secretary in this program.

S. 3466 in Section 5, "Registration and Regulation of Fuels and Fuel Additives," grants the Federal Government the authority to establish standards for fuel composition or additives. We believe such authority to be entirely undesirable.

It would appear to us that the Government, as has been done for automotive emissions to date, should set emission standards and permit industry in this competitive enterprise system to devise the lowest cost methods to meet such standards. The consumer then will gain in securing the desired results at the lowest possible cost.

In conclusion, we recommend enactment of S. 3229 and, in turn, no action on S. 3466.

Sincerely,

JAMES H. PIPKIN.

SUMMARY OF STATEMENT OF JOHN O. LOGAN AND C. G. GERHOLD OF UNIVERSAL OIL PRODUCTS CO., DES PLAINES, ILL., WASHINGTON, D.C., MARCH 20, 1970

I am John O. Logan, President of Universal Oil Products Company of Des Plaines, Illinois. I have with me C. G. Gerhold, my assistant and W. H. Thomas, UOP's Washington representative. For the benefit of those who may not be closely familiar with our company, it is a 57 year old organization orginally founded to research, develop and license processes for use by the petroleum refining industry. It has since grown into a diversified international organization, operating in a number of fields, with 12,000 employees and total sales of approximately $450,000,000. However, its original research and development activity continues to be an important part of its business. Testimony to UOP's achievements in petroleum refining technology are the almost 1800 licensed units operating in 75 countries around the world and the pool of 6000 active patents, mostly in the petroleum and petrochemical fields.

California is to be commended on the manner in which it pioneered and is continuing its aggressive leadership in the area of air pollution control. Our company has also been active in this field and was one of the original group of companies which applied for and received certification from the California Motor Vehicle Pollution Control Board for automobile exhaust emission control devices at a time when many others thought that such approaches were unnecessary or impractical.

UOP has devoted a considerable amount of these activities and its R & D facilities to the problems of reducing the air pollution resulting from the internal combustion engine. Over the past ten years, its investment in this type of research has amounted to nearly ten million dollars. These activities have resulted in the development of catalytic exhaust converter devices which are effective in the removal of contaminants from automotive exhaust.

In connection with these activities, we have become convinced that the internal combustion engine in the general form presently used in passenger vehicles is capable of being converted from its current role as the principal air polluter to a position in which its contribution to environmental pollution will be extremely minor. We have also become convinced that this can only be accomplished by a systems approach to the whole problem. The piecemeal approaches which have been taken up to now will continue to prove inadequate for the total job.

Specifically, we believe that the elimination of pollutants emitted from the vehicle exhaust will require the combination of suitable vehicle and engine designs, the tailoring and accurate control of the fuel, and use of a properly designed catalytic converter system employing catalyst with optimum properties. All of these must be done jointly to obtain the best overall results.

In this connection I would like to now present several charts showing some recent results obtained in our laboratory which indicate the kind of emissions control obtainable through a systems approach to the problem.

These data resulted from the installation of one of our catalytic converters on a standard vehicle with modified carburetion using one of our experimental catalysts and employing lead-free gasoline. A single catalyst was used in this installation and no secondary air injection or exhaust gas recycle were used to obtain these results.

The first curve shows the substantial conversion and effective control of nitrogen oxide which was obtained under these conditions. The second and third curves show the low levels of hydrocarbons and carbon monoxide which were obtained simultaneously.

In considering these data, we would like to point out that they are not believed to be in any sense optimum, but do indicate the direction in which we think effort should be concentrated if vehicles are to be produced which will minimize emission levels of all the objectionable pollutants. It should also be borne in mind that the results were obtained without the changes which are being seriously considered for commercial adoption and which will sacrifice performance or fuel economy for moderately reduced nitrogen oxide emission levels. The next chart shows that these results are obtainable only when the engine is controlled to average around the stoichiometric air to fuel ratio, that is, operated without either excess air or fuel. Under these conditions, the emissions of nitrogen oxides directly from the engine are nearly maximum, but because of the substantially better operation of the catalyst system with such an exhaust gas, the overall results involve a minimum of nitrogen oxide as well as other pollutant emission levels from the vehicle. These low levels would not have been obtainable if the nitrogen oxides from the engine had been minimized.

As we pointed out above, the results shown were obtained using a nonleaded gasoline. We have not been able to obtain similar results when lead is a part of the fuel. We therefore believe that the elimination of lead from the gasoline is a highly desirable part of a total systems approach to the solving of the problem. In connection with the practicability of elimination of lead from gasoline, we would like to review briefly some additional charts which we have prepared in this connection and which have been used in earlier testimony before a committee of the California Legislature. The first chart shows the historical record of octane quality of both premium and regular grades of gasoline. It points out the relatively minor role which lead plays in producing octane quality at the present time. The next chart compares the performance of exhaust converters on leaded and unleaded gasoline and demonstrates the much superior performance and stability obtained when using a lead-free fuel. The final chart indicates our best estimates of the costs which would be involved in the substitution of octane numbers obtained by additional refining as a substitute for the addition of lead. These costs are for a 90,000 bbl/day California refinery and also indicate the capital requirements which would be involved in making such a change. These figures represent the costs which would be involved if gasolines of present top octane quality were produced. Current proposals for producing nonleaded gasolines at somewhat lower octane numbers would, of course, entail correspondingly lower costs. Our figures, when put on a national basis, would represent a total investment of between two and two and one-half billion dollars. The per gallon cost figures would be similar to those which we have shown. All of these figures are based on the production of gasoline of the same octane quality as is now being produced with the addition of lead.

It should be recognized that the foregoing figures will vary somewhat for specific refineries. This variation will depend upon feed stock, the present type and degree of refining and somewhat on the size of the refinery. In general, smaller units would probably have a proportionately greater capital and operating cost.

We are quite aware that these figures are considerably lower than those which have been widely publicized by others; however, we have carefully reviewed our figures and compared them in detail with other studies. We are convinced that if full advantage is taken of available modern technology, our numbers are sound. It is an essential part of UOP's licensing business to provide refiners with accurate processing costs involved in the use of our licensed processes, and our success in the petroleum field testifies to the quality of our estimates.

In summary, UOP feels it is perfectly possible to reduce emissions of hydrocarbons, carbon monoxide and nitrogen oxides simultaneously to extremely low levels. These results are attainable without seriously sacrificing either engine performance or gasoline mileage. We are, however, skeptical that this will be attained unless a more unified approach to this whole problem is undertaken using, cooperatively, all of the available technology and skills in the fields of automotive design, catalyst container design, catalyst formulation and fuel production. One of the worst barriers to this kind of progress is the so-called NIH (not invented here) factor in which organizations and individuals tend to depreciate or ignore the contributions previously made by others.

Our company feels strongly about another point. It is urgent that steps be taken promptly to modernize and set up definite discrimiating testing procedures and performance standards. This step is vital if organizations working in this area are to know what their targets are. It should also do much to minimize the possibility of adopting systems of actual mediocre effectiveness, but which appear to perform well because of unrealistic weighting factors or because performance during the measured modes was better than that throughout a more complete range of driving modes. Our company has repeatedly pointed out to various government bodies our objections to the established performance standards, but progress in recognizing these objections has been painfully slow.

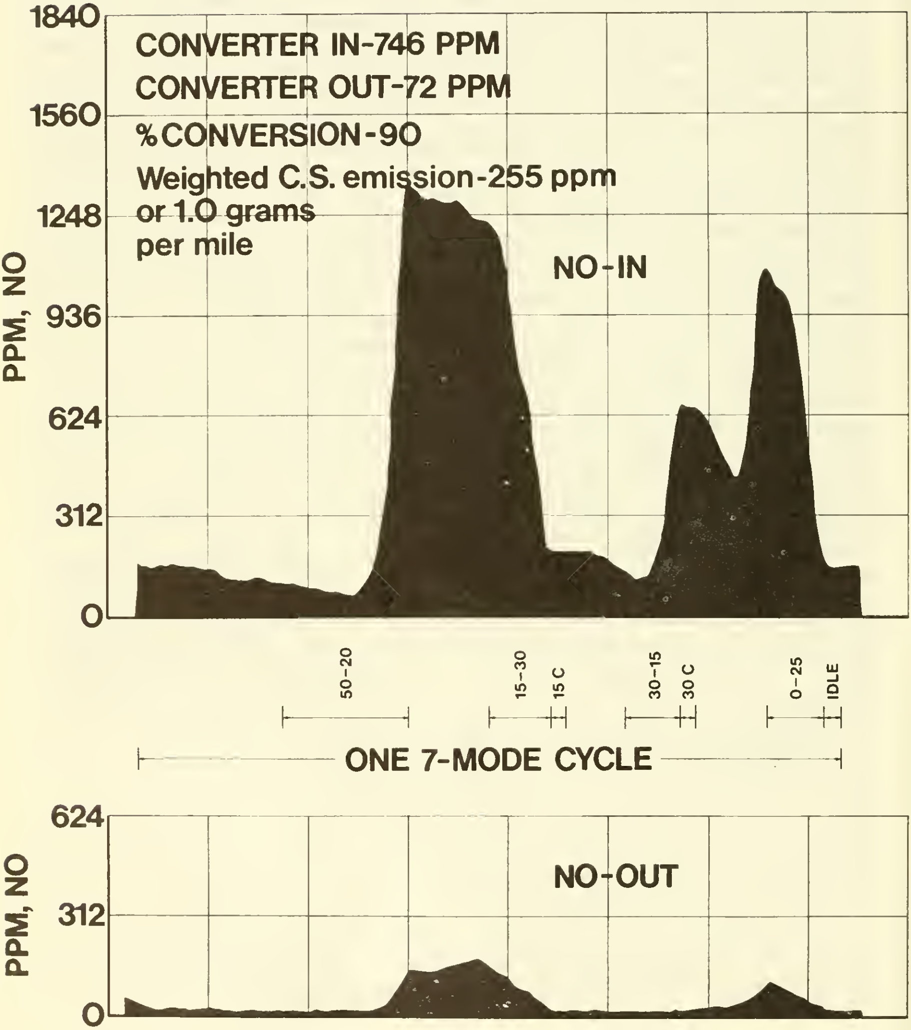
We note that consideration is being given to the limitation of other components of gasoline aside from the lead—specifically, olefins and aromatics. In employing the kind of procedures which we used in our studies there was rather substantial reduction in the olefinicity of the products by about one-third of the base case level. Aromatics were, in general, increased by the additional refining. We believe that extreme caution should be used in setting too severe a limitation on aromatic content. The principal reason for considering the limitation on or removal of lead from gasoline at the present time lies in the more complete removal of the hydrocarbons from the exhaust by catalytic devices when used with nonleaded gasoline. Increase in the concentration of aromatics in the gasoline results in only a slight increase, in the concentration leaving the engine. This is very substantially further reduced by catalytic devices. Thus, we believe that if the prime consideration is emission of aromatic hydrocarbons to the atmosphere, the question of the aromaticity of the fuel in vehicles equipped with a catalytic device is of little importance for converter-equipped vehicles.

One specific aspect of the aromaticity which has been raised is the presence of carcinogenic polynuclear hydrocarbons in automotive exhaust. Our data indicate that such polynuclears will be present in the exhaust only if high-boiling aromatics are present in the fuel and that these fractions, which constitute a very small percentage of the total gasoline, can be removed from it by the incorporation of a simple distillation step at a low cost. Again, even if these materials are not removed from the fuel or completely destroyed by the engine, our data indicates that catalytic devices would do a very acceptable job in removing them from the exhaust.

In summary, UOP feels it is perfectly possible to reduce emissions of hydrocarbons, carbon monoxide and nitrogen oxides simultaneously to extremely low levels. These results are attainable without seriously sacrificing either engine performance or gasoline mileage. We are, however, skeptical that this will be attained unless a more unified approach to this whole problem is undertaken using, cooperatively, all of the available technology and skills in the fields of automotive design, catalyst container design, catalyst formulation and fuel production.

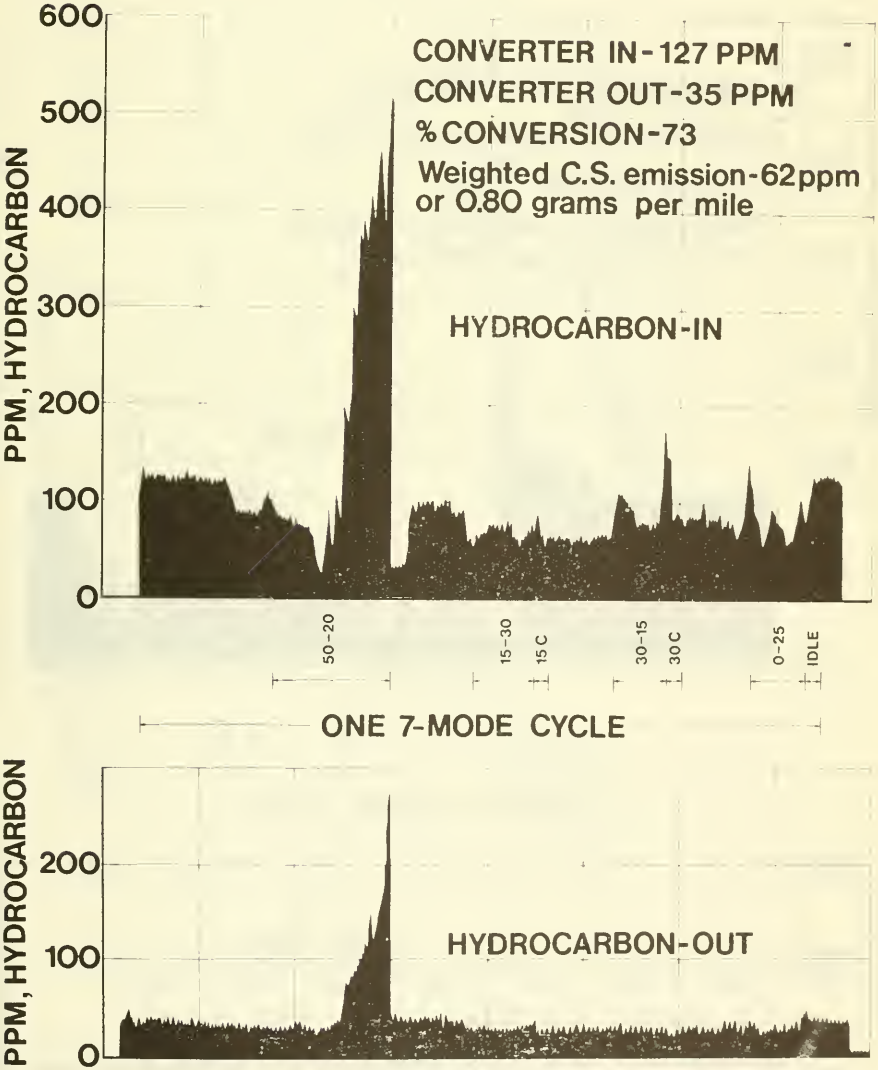
(Charts referred to follow:)

NO$_X$ EMISSION
HOT CYCLES



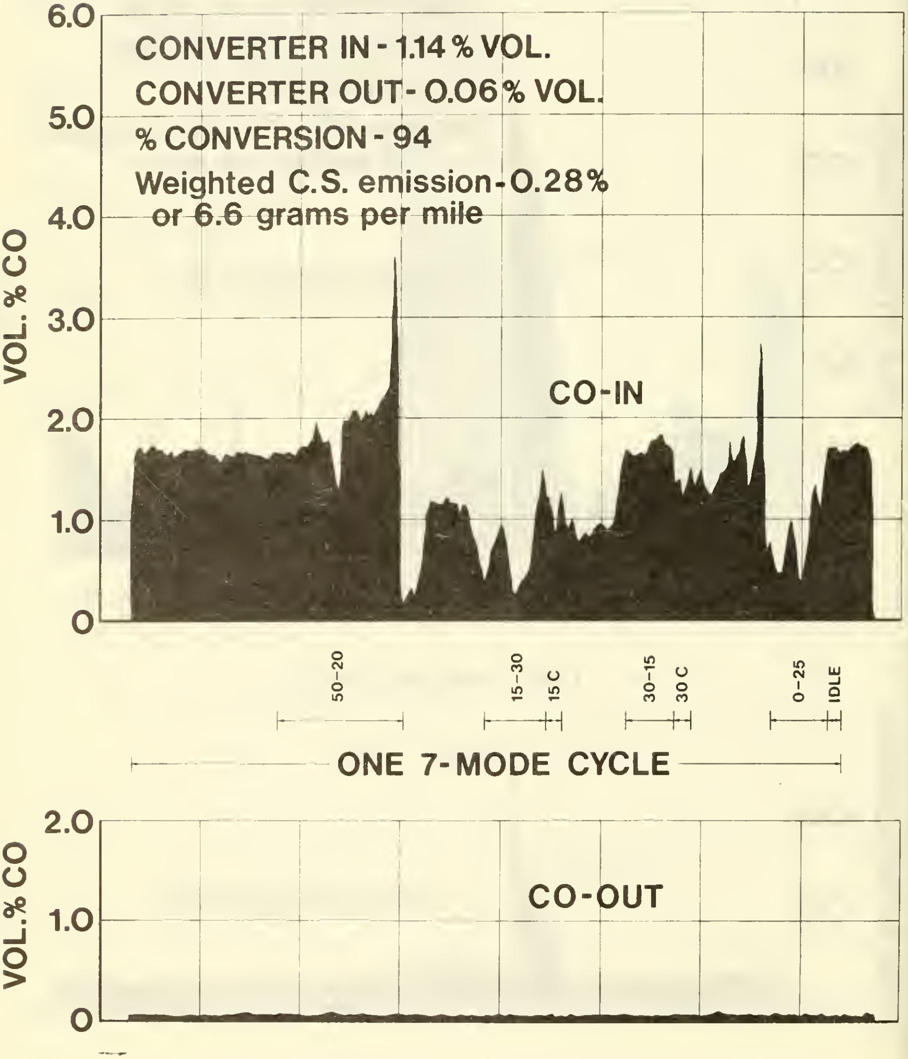
CONVERTER IN-746 PPM
CONVERTER OUT-72 PPM
%CONVERSION-90
Weighted C.S. emission-255 ppm
or 1.0 grams
per mile

HYDROCARBON EMISSION
HOT CYCLES

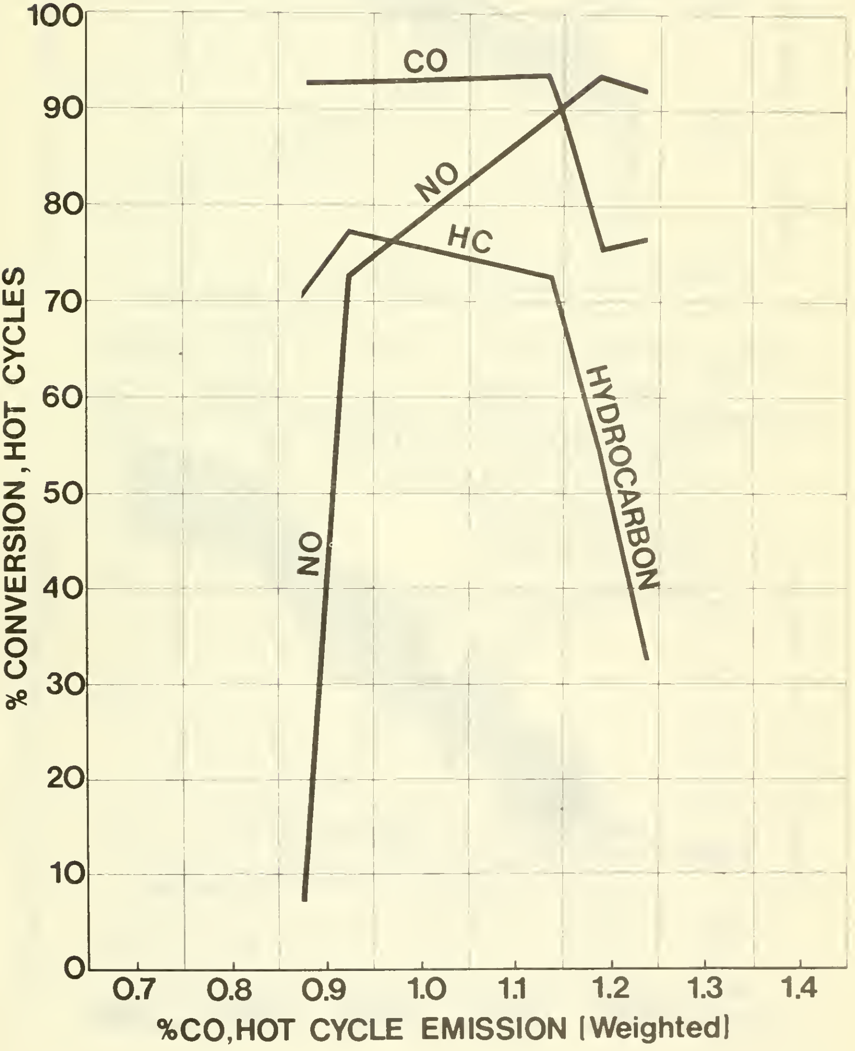


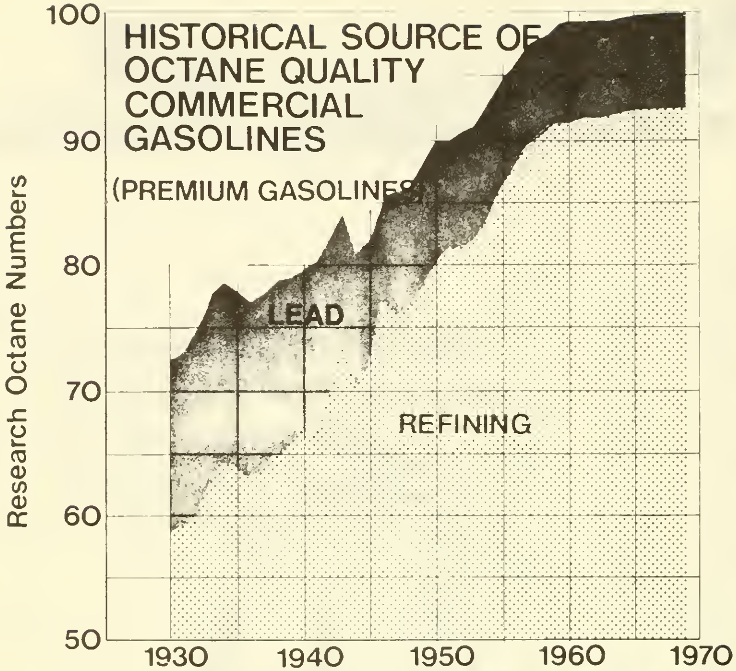
CONVERTER IN - 127 PPM
CONVERTER OUT - 35 PPM
% CONVERSION - 73
Weighted C.S. emission - 62 ppm
or 0.80 grams per mile

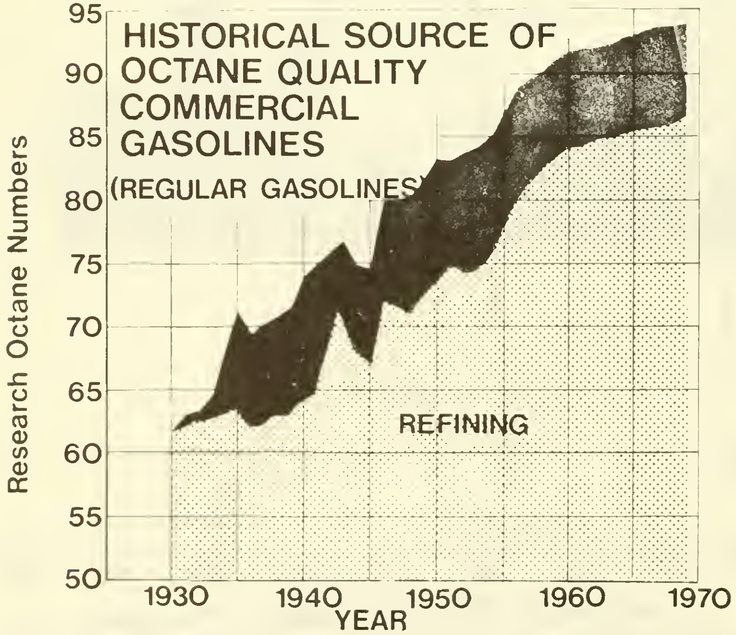
CO EMISSION
HOT CYCLES


CONVERTER IN - 1.14 % VOL.
CONVERTER OUT - 0.06 % VOL.
% CONVERSION - 94
Weighted C.S. emission - 0.28 %
or 6.6 grams per mile

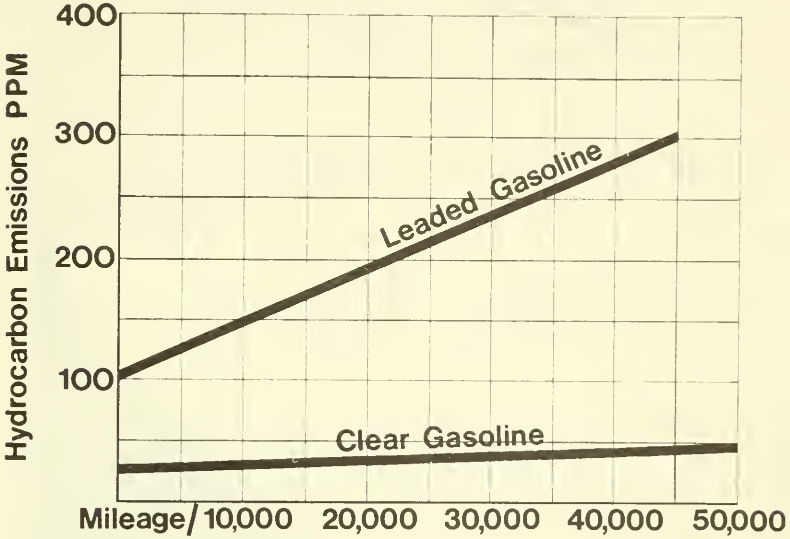
HOT CYCLE CONVERSION VS CARBURETION



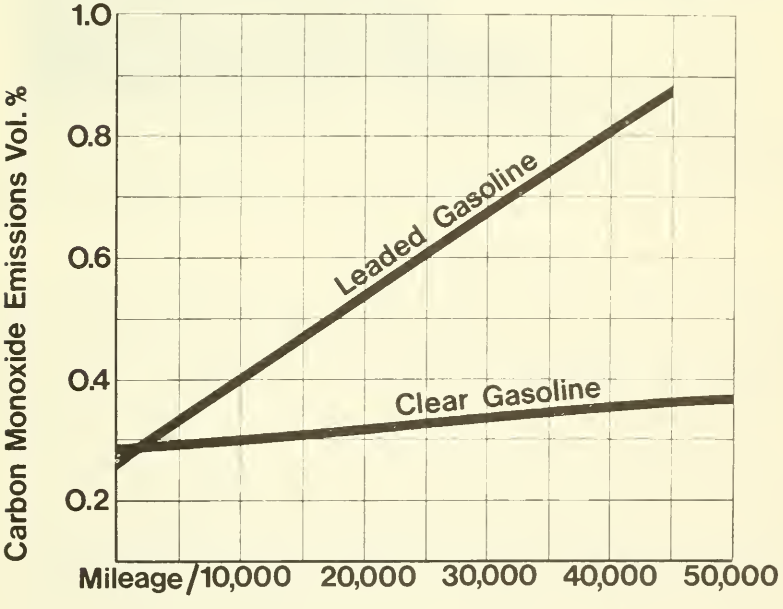

HISTORICAL SOURCE OF OCTANE QUALITY COMMERCIAL GASOLINES
(PREMIUM GASOLINES)
LEAD
REFINING
Research Octane Numbers
100
90
80
70
60
50
1930
1940
1950
1960
1970


HISTORICAL SOURCE OF OCTANE QUALITY COMMERCIAL GASOLINES
(REGULAR GASOLINES)
REFINING
Research Octane Numbers
95
90
85
80
75
70
65
60
55
50
1930
1940
1950
1960
1970
YEAR

TYPICAL VEHICLE EMISSIONS WITH A CATALYTIC CONVERTER



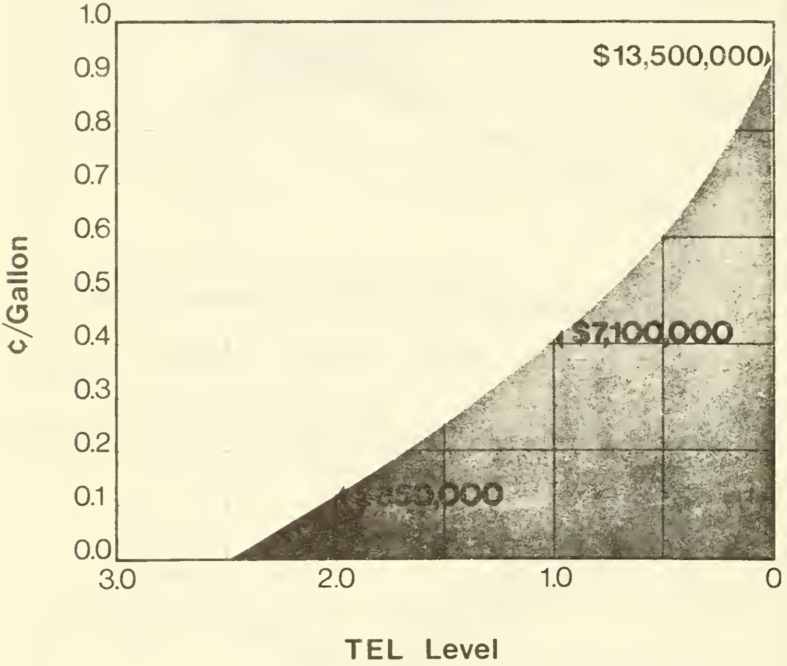
Carbon Monoxide Emissions, Volume%



g. 3

COST OF LEAD REMOVAL FROM GASOLINE

¢/Gallon vs Lead Level



U.S. SENATE,
Washington, D.C., May 6, 1970.

Hon. EDMUND MUSKIE,
Chairman, Subcommittee on Air and Water Pollution, Committee on Public Works, U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: In connection with your current hearings on air pollution, I am forwarding for your consideration and possible inclusion in your hearing record an article on lead poisoning forwarded to me by Dr. George W. Harvey, Chief Scientist of the Marine Ecology Division, Oceanic Institute, University of Hawaii.

Entitled "Lead Poisoning, An Old Problem with a New Dimension," the article contains a number of sections on the effect of lead poisoning on health, which is pertinent to your Subcommittee's study.

With kind regards and aloha,

Sincerely yours,

HIRAM L. FONG.

CHAPTER 4.—LEAD POISONING. AN OLD PROBLEM WITH A NEW DIMENSION

(By P. B. Hammond)

I. INTRODUCTION

This essay is about one of the most notorious poisons known to man. Down through the years, there has been more written about clinical lead poisoning in man and domesticated animals than about poisoning by any other agent. The magnitude of the problem of lead poisoning in occupational settings led to much of the early industrial hygiene legislation and to a great deal of toxicological research. Yet here we stand today still worrying about it. The "new dimension" alluded to in the title is one of general environmental pollution. Actually, concern with the consequences of exposure of the general population to lead is new only in the historical perspective as applies to lead. Recognition of the potential hazards from general dissemination of lead in the environment actually antedates the recent furor over chlorinated hydrocarbon pesticides.

Since we have a broad acquaintance with the toxic properties of lead at all levels of human and animal exposure, the experience may prove of value to those confronted with similar problems involving other toxicants.

It is not possible to be all things to all men in toxicology or anywhere else. I hope my readers will be tolerant with me for being superficial where they expected depth and tedious where they expected to be treated to a panoramic view of the problem, uncluttered by bothersome detail. And for those with selective appetites a menu is provided.

II. HISTORICAL BACKGROUND

The toxic properties of lead were recognized as far back as the second century B.C. when Nicander described classical signs of poisoning among men mining and refining lead. Dioscroides, who lived in the first century A.D., also recognized the significance of lead as an occupational poison. Yet, effective control measures in industry were not widely instituted in the United States and Western Europe until the present century. Although a lack of concern for the lot of the working man was a strong factor, poor dissemination of existing knowledge was no doubt also involved.

The widespread early use of lead by man is readily understood in light of its many desirable properties. Lead is relatively easily refined from natural ores. It is also quite malleable and resistant corrosion. For these reasons, it found extensive application in both Greek and Roman culture. Lead was used for the manufacture of the cooking utensils of the wealthy and the extensive planning systems in their homes were constructed of lead pipes. It has recently been suggested that Roman civilization deteriorated very largely as a result of extensive lead poisoning in the ruling class. The high incidence of mental retardation, infant mortality, and sterility among the wealthy is cited in support of this theory. Preliminary data showing high concentration of lead in the bones of wealthy Romans has encouraged more extensive investigation of this interesting suggestion (1).

In medieval times, the practice of "sweetening" wine with lead or lead acetate led to such a serious toxicological problem that the death penalty was imposed on occasion for adulteration of wine with lead. Even today, alcoholic beverages of illicit origin are occasionally incriminated as the source of poisoning. Old automobile radiators are often used as the condenser component in illicit stills. These contain enough solder to cause dangerous contamination of the "moonshine." Some practitioners of the art even add old battery plates to the brew to improve the flavor.

III. INDUSTRIAL LEAD POISONING

With the ever-accelerating inventiveness of man came a rapid expansion in both the demand and diversity of applications for lead. By the end of the nineteenth century, a substantial clinical literature had accumulated describing poisoning, mainly in the lead-using industries where the cause was clearly apparent and the effects sufficiently dramatic (and tragic) to command attention. Such pioneer investigators as Legge in England, Teleky and Lehmann in Germany, and Aub, Minot, Reznikoff, and Fairhall in the United States initiated extensive studies concerning the toxic effects and metabolism of lead. In 1926 Aub *et al.* summarized this early literature in a 265 page treatise entitled "Lead Poisoning" (2). The more serious hazards in industry were gradually reduced as understanding of the nature of the problem improved and as more diagnostic techniques were developed which made it possible to identify hazardous exposure in its early stages. Crippling neurological manifestations of lead poisoning such as palsy and encephalopathy are now rarely seen. The earlier, more readily reversible signs such as colic, fatigue, and loss of appetite are generally identified before more serious mischief can be done. Industrial physicians consider occupational lead intoxication to be a mild disease, as it is seen today. The current incidence of industrial lead poisoning is not known with any precision, but it is probably much lower than it was twenty or thirty years ago, and the cases encountered are clearly less serious.

Perhaps a more thorough search of the literature would have unearthed some interesting historical notes concerning lead poisoning in infants. In any event, it seems reasonably certain that this form of lead poisoning was not widely recognized until about twenty years ago. The incidence seen at Cincinnati Children's Hospital and Cincinnati General Hospital rose from single cases in 1941, 1943, and 1946 to an anual rate of 10-23 from 1950 through 1968 (3). Similar rises have been reported during the period 1950-1956 in Washington D.C. (4) and during the periods of 1954-1964 in New York City (5). Rises in "incidence" have invariably been the result of the initiation of case-finding programs, and the problem has probably really existed unrecognized for as many years as have the long-standing conditions of exposure. The disease prevails mainly in infants ranging in age from 1-4 years. The source of poisoning almost invariably is flaking paint or crumbling plaster. Needless to say, most cases occur in the slums where poor upkeep of property prevails. Pica (the tendency to chew on inedible material), is an essential component of the etiologic setting. Unlike the occupational disease of adults, lead poisoning in infants, even as seen today, is quite severe. In its milder form abdominal pain, constipation and lethargy are common signs. With more intense or prolonged ingestion of lead, disturbances of the central nervous system become more pronounced. Using modern forms of therapy, the mortality rate is generally 22–65%, although in the most recent series reported it was only 4.5% of the severe cases treated (6). The neurological sequelae are possibly even more tragic than the deaths. In a recent study of a series of cases in the Chicago area, 39% of the 425 cases exhibited persistent sequelae ranging in severity from optic atrophy and grand mal seizures to profound mental-retardation (7).

V. LEAD POISONING IN DOMESTICATED ANIMALS AND WILDLIFE

Domesticated animals have been exposed to substantial amounts of lead in their environment and episodes of intoxication have been described. The inadequacies of case-finding procedures which obscure the true picture of lead poisoning in man are even more discouraging when one attempts to define the problem in animals. At one time, when horses were the main source of motive power, lead poisoning was widely recognized to occur in that species. Most of the cases reported in this country were from the lead-mining and smelting areas. Affected animals were called "roarers," a term describing the rattling sound originating in the larynx during inspiration. Paralysis of the laryngeal nerves resulted in failure of normal abductior of the laryngeal cartilages during inspiration. The usual cause of death was gangrenous pneumonia, presumably resulting from failure of the epiglottis to close properly during the act of swallowing (8). In the pre-DDT era, lead arsenate was used very extensively as a pesticide, particularly in fruit orchards and was a common source of poisoning. Lead poisoning in horses has become a rarity, largely because lead is now far more effectively scrubbed from smelter fumes and because the use of lead arsenate is far less common than it used to be. My own experience with clinical lead poisoning extends back to 1953. During that time I have encountered only one episode of lead poisoning in horses and have heard about no others.

In recent years lead poisoning among domesticated animals has been almost exclusively a disease of cattle. The factors combining to single out cattle among the domesticated species are much the same as the ones that favor lead poisoning in infants. Cattle are by nature extremely curious. Foreign objects are investigated often on a herd-wide basis. This usually takes the form of extensive licking and chewing. Lead-bearing paints, plasters, greases, and old storage batteries are usually incriminated. The syndrome is acute and involves various derangements of the central nervous system. Mortality and morbidity statistics are not adequate to estimate nationwide losses, but the clinical records at the University of Minnesota College of Veterinary Medicine indicate that lead poisoning has been the most common toxicological problem of cattle over the past ten years. In a recent Irish survey of postmortem material from 519 adult cattle and 390 calves submitted to a rendering works, analyses for lead in the kidney were clearly compatible with a diagnosis of lead poisoning in 1.7% of the adults and in 4.5% of the calves (9).

Wild animals are generally sufficiently isolated from the usual sources of lead so as to effectively avoid the toxicological problems of man and domesticated animals. The obvious exception is the hunter's bullet. Actually, death by trauma is not the only hazard imposed by the hunter. Wild waterfowl succumb to the toxic effects of shotgun pellets by oral intake. The factors conspiring against waterfowl concern their feeding and digestive peculiarities. Some lakes located along the more popular migratory flyways have been shot over so much that a very appreciable concentration of lead shot had accumulated on the lake bottoms. The remaining factors are inherent peculiarities of avian physiology. Grit serves as a substitute for teeth. Waterfowl, particularly those which normally feed on tuberous roots, get their grit from the bottoms of lakes and streams. Lead shot serves well as grit and is retained by ducks for an average of 18 days per shot. Enough lead is absorbed from even a single #6 shot to weaken seriously or to kill a Mallard duck. It has recently been estimated that 2–3% of the wild waterfowl population is lost as a result of lead poisoning (10). The obvious long-range solution is the banning of lead shot. Iron shot is claimed to be a reasonable substitute, but voluntary substitution for lead shot is not likely because the investment involved in re-tooling discourages commercial production.

VI. SOURCES AND USES OF LEAD

It is abundantly clear that the common forms of lead poisoning result from the mining, processing and commercial dissemination of lead. Lead in its native state has never been the source of poisoning. This is in contrast to certain other metals which have caused loss of life without the influence of man being involved in any direct fashion. The outstanding examples which come to mind are copper and selenium, both of which are accumulated by some plants from virgin soils to a degree fatal to grazing livestock.

The amount of lead produced annually in the United States is more than one million tons. Over the past fifteen years there has been little change in total annual consumption, but the pattern of use has changed. The use of metal products made of lead has declined, as has the use of lead pigments. These declining categories have been replaced by two items which reflect the rapidly expanding use of the automobile: storage batteries and tetraethyl lead (TEL), which is used as an antiknock fuel additive. TEL represented roughly 20% of U.S. lead consumption in 1966. Its contribution to environmental contamination is actually even greater than would be suggested by consumption figures.

It has been estimated that roughly 70–80% of the TEL in motor fuel is eventually exhausted into the atmosphere to be either inhaled directly or deposited on vegetation, soil, and water (11). By contrast, much of the lead in the other categories is recovered and recycled into domestic production. In 1966, roughly 537,000 tons of lead were derived from scrap (Mineral Yearbook, 1966). That lead is mainly recovered from metal products and batteries. By subtracting recovered lead from lead consumed, we arrive at a figure which represents annual net addition of lead to the environment. Assuming that 75% of the lead in TEL is nonrecoverable, the TEL contribution to the environment in 1966 would be 0.75 × 247,000 or 185,250 tons, or 26% of the lead added from industrial sources. Actually, the term "industrial sources," as used up to this point, has not included industrial activity in which lead is an incidental by-product. Fly ash from the burning of coal, for example, contains lead. The annual contribution of lead to the air from this source is uncertain, but assuming a figure of 3×10^{11}gm/yr (12) and a lead concentration of 100 ppm, only 33 tons would originate from flu gas.

	Tons
Consumed	1, 277, 000
Recovered	−573, 000
Added to the environment	704, 000

VII. TETRAETHYL LEAD AND THE GENERAL ENVIRONMENT

TEL was introduced as an automotive fuel additive in 1923. Its use very rapidly became a cause for concern. A number of deaths and more cases of nonlethal intoxication occurred among those occupationally exposed. Apprehension also developed concerning possible toxic effects in the general public if its use were to become extensive. A conference was convened in Washington May 20, 1925. The title given to the published proceedings was "Proceedings of a Conference to Determine Whether or Not There is a Public Health Question in the Manufacture, Distribution, or Use of Tetraethyl Lead Gasoline" (13). Representatives of labor, industry, government, and of the academic community participated. In accordance with their recommendation, the Surgeon General appointed a committee of seven authorities in medicine, physiology, and industrial hygiene to study the issue. A set of proposed reglations based on the recommendations of the advisory committee was formulated in 1926. These were concerned only with precautions to be taken in the manufacture, distribution, and handling by the distributor. The proposed regulations were adopted voluntarily by the petroleum industry. So far as occupational hazard is concerned, the record has been quite good. There have been only 88 cases of TEL poisoning reported in the United States and Canada subsequent to adoption of the regulations. Of these, 16 have been fatal (14). This is not bad, considering that several million tons of tetraethyl lead have been manufactured, distributed, and used since 1926.

TABLE I.—LEAD CONSUMPTION IN THE UNITED STATES [1]

[Thousands of short tons]

	1951	1956	1961	1966
Metal products	500	490	359	397
Storage batteries	375	370	368	472
Pigments	140	120	95	117
Antiknock fuel additive	128	192	170	247
Other	42	38	35	44
Total	1, 185	1, 210	1, 027	1, 277

[1] U.S. Bureau of Mines, Minerals Yearbook.

The committee could find no reasonable grounds for prohibition of the use of TEL in automotive fuel. But, the committee was careful to emphasize the provisional nature of its recommendations, particularly in regard to the possible future hazard of leaded gasoline to the general public. Very limited data were available at that time concerning the consequences for the health of the general public. These had been gathered hurriedly by the committee utilizing the services and personnel of the United States Public Health Service. Its views are quoted from the report (15).

"A more extensive study was not possible on account of the limited time. It remains possible that, if the use of leaded gasolines becomes widespread, conditions may arise very different from those studied by us which would render its use more of a hazard than would appear to be the case from this investigation. Longer experience may show that even such slight storage of lead as was observed in these studies may lead eventually in susceptible individuals to recognizable lead poisoning or to chronic degenerative diseases of a less obvious character. In view of such possibilities, the committee feels that the investigations begun under their direction must not be allowed to lapse."

A new dimension to the lead poisoning problem was identified. A respected body of scientists had in the strongest terms gone on record as urging that we start doing something about a potential problem before serious damage was done. The motivation was conditioned by the fact that this new application of lead involved exposure of the whole population. The call to action did not go completely unheeded. A systematic attack on the significance of lead as a hazard to the general population was begun about 1930 at the University of Cincinnati under the leadership of R. A. Kehoe. The impetus and support for the studies stemmed directly from the questions posed as a result of the introduction of tetraethyl lead. Through the period 1930–1960, hardly anyone else was seemingly much interested in the source and metabolism of lead in the general population.

The whole matter came up for review in 1958 when the Ethyl Corporation sought the advice of the United States Public Health Service in regard to a proposed increase in the concentration of TEL in gasoline. In conformity with past practice, the Surgeon General appointed an *Ad Hoc* Committee on Tetraethyl Lead to study the matter. This committee recommended that a graduated schedule of increase be allowed. More important, the committee found it "regrettable that the investigations recommended by the Surgeon General's Committee in 1926 were not carried out by the Public Health Service" (16). Quoting further,

"If data were now available on body lead burdens, with 1926 as a baseline, a more objective decision would have been possible. Such studies should be undertaken without further delay to assure the validity of the present decision and to guide future committees, particularly since some authorities believe that the tolerable limit of lead absorption is being approached."

It seems unfortunate that an equally strong recommendation was not made in regard to the need for studies which would make it possible to better interpret body burden data.

The new dimension in regard to the lead problem which has arisen with the growing use of tetraethyl lead is quite like the one resulting from the widespread use of chlorinated hydrocarbon pesticides. Both substances are acknowledged poisons and both are now widely disseminated in the environment. The similarity does not end there. Both lead and the chlorinated hydrocarbon pesticides persist for long periods both in the body and in the environment. The corollary of persistence is accumulation, which compounds the potential problems. There has been no Rachel Carson to foment public agitation against leaded gasoline and lead shotgun pellets. But there has been one strong blast of criticism leveled at the United States Public Health Service for accepting the current level of lead contamination in the general population as not significant from the standpoint of possible intoxication.

A geochemist who has studied trace amounts of lead in the earth, oceans, and in the atmosphere has made calculations purporting to show that the contribution of human activity to the amount of lead in man's environment has been overwhelming in comparison to the natural level (12). Patterson calculates the "natural" body burden of lead and contrasts it with the prevailing burden. Then, comparing the minimal blood level of lead in clinically recognizable poisoning to that of the average modern man he concludes that these are perilously close together in contrast to the likely level of a "natural" man. In his view, the American people are being subjected to "chronic lead insult." Needless to say, this evaluation of the situation evoked a vigorous response in the scientific community mostly critical in so far as public health officials and toxicologists were concerned. A possible fundamental fallacy of his argument is the assumption that lead toxicity is a continuum, more or less arithmetically proportional in intensity to the body burden with the point of zero toxicity lying at some point quite remote from present levels. It would be almost impossible to prove conclusively that the current average body burden is not harmful. To do so would require that we find or create for epidemiological comparison a group of essentially lead-free people differing in no other material respect from people having an average body burden of lead. This would be extremely difficult to accomplish. Lead is so ubiquitous as to be virtually impossible to eliminate without grossly altering numerous other environmental factors, thereby making the comparison invalid or at least making it extremely difficult to interpret.

VIII. PERSPECTIVES REGARDING PROBLEM-SOLVING

The best and most direct solutions to toxicological problems often do not require an input of research. Rather, they require sound programs in public health, education, and technology. We could very largely eliminate lead poisoning in infants by eliminating slums and by searching more diligently for the children who are acquiring a dangerous amount of lead. We could do the same in regard to occupational lead poisoning by more rigorous hygienic supervision and monitoring of the working environment and of the workers themselves. We could perhaps appreciably reduce the lead burden of the general population by banning or greatly curtailing the mining and commercial uses of lead. In all cases, the economic price must be balanced against the potential health benefits. In the case of occupational lead poisoning, better programs of industrial hygiene, particularly in the smaller operations, would probably virtually eliminate what is now a mild disease anyway. In case of lead poisoning in infants and cattle the prospects for eradicating the sources of poisoning are far less promising. Therefore, more research concerning the causative factors and concerning effective therapeutic measures are needed.

The most difficult problem of all is with regard to the hazards attending the body burden of lead in the general population. There is no clear evidence that we are at risk, but there is likewise no evidence that we are not. Would we be healthier than we are now if our body burden were reduced by a factor of ten or a hundred?

It is with this question in mind that the toxicology or lead must be reviewed.

IX. CURRENT KNOWLEDGE BEARING ON EXISTING PROBLEMS

For purposes of review, current knowledge can be subdivided into considerations relating to (a), lead metabolism and (b), toxic actions. By way of general comment it should be pointed out that the form of lead is an important determinant of its biological behavior. This is most glaringly apparent in the case of alkyl lead compounds, such as tetraethyl lead. These are readily absorbed from the intact skin and mucous membranes. They are preferentially distributed to lipid phases in the body, including the brain. These special features confer on alkyl lead compounds a high degree of toxicity which is of a different character from that seen to result from poisoning by inorganic forms of lead. Reference has been made earlier to the major contribution of alkyl leads to total annual consumption. Virtually all of this is destroyed in the combustion process, however. Alkyl lead poisoning, then, is a specialized problem unique to the small group of occupationally exposed individuals and will not be considered further. Except where indicated otherwise, the term lead will therefore refer to the inorganic forms. Except in so far as concerns absorption characteristics, the form of inorganic lead to which the body is exposed is not considered to have any bearing on its metabolism, excretion or toxic action.

X. THE METABOLISM OF LEAD

A. Absorption

The two major routes of entry are the gastrointestinal tract and the lungs. Dermal absorption of inorganic lead is insignificant, although cases of presumed toxicity from dermal application are on record in the older literature. Most of these resulted from application of lead preparations to ulcerated, burned, or otherwise denuded areas.

Net absorption of lead from the gastrointestinal tract has been found to be quite low in those species which have been studied, and the per cent absorption doesn't appear to be materially influenced by the dosage administered. Apparent, or net absorption of lead in sheep is approximately 1.3% over a range of 2–108 mg Pb/day and is quite similar for rabbits (17).

In man, under conditions of normal or near-normal dietary intake, approximately 6–7% of the metal is absorbed (18). The importance of the nature of the lead salt as a determinant of absorption characteristics has not been defined with any precision, but for the general spectrum of forms in which lead is ingested, this factor is of little consequence. In a series of calves poisoned with lead little difference was found regarding the lethal dose or blood lead concentration when the lead was administered in the form of the acetate, phosphate, oxide, carbonate, or even as dried flakes of paint. Only in the case of metallic lead and lead sulfide (as galena ore) did the chemical state significantly influence absorption (19).

Very little is known concerning the mechanism whereby lead is transported across the gut mucosa into the systemtic circulation. The level of calcium in the diet has a considerable influence on the degree of absorption, high concentrations depressing the absorption of lead. This may involve a competitive mechanism at the level of the gut mucosa since the absorption of lead, like that of calcium is enhanced by vitamin D (20).

Absorption of lead from the respiratory tract has long been under study. Back in the days when industrial exposure was of paramount concern, it was recognized that the inhalation of lead could occur. The experimental approaches used for demonstrating absorption from the lungs were crude by present standards, particularly in regard to the influence of particle size on absorption. In recent years, a reasonably detailed body of information has accumulated, particularly as concerns man himself. Most of this has been gathered utilizing concentration of lead considerably higher than those found in urban air. The major contributions regarding the absorption of lead from the respiratory tract in man originate from Kehoe's group at the University of Cincinnati. Using atmospheric concentrations of lead approximately 50 to 100 times higher than those generally found in urban air, it was found that approximately 36–46% of the inhaled lead was retained. Not all of this was deposited in the lungs. Particle size has a considerable influence on the lead retained.

When 90% of the particles were in the range of 0.01 to 0.1 μ in diameter, virtually all the lead retained was absorbed from the lungs. On the other hand, when the mean particle diameter was 0.9 μ, approximately 40% of the lead retained was trapped in the upper respiratory tract and swallowed (18). In a study of the range of particle size for lead in urban air, 40% exceeded a diameter of 0.45 μ (21). Therefore, much of the lead retained is probably actually swallowed. From that point on, it essentially behaves like ingested lead. In a study of the retention of inhaled lead in both occupational and urban settings, the retention of inhaled lead was 37–47% which is almost identical to Kehoe's results (22). Unfortunately, particle size was not determined in this study. Kehoe made his studies using lead oxide, generated by burning tetraethyl lead. Actually, the lead exhausted into the atmosphere by automobiles is largely PhCl•Br, which is probably at least as well absorbed as the oxide (23). Additional studies are needed concerning the particle size distribution below the level of 1 μ before a good estimate can be made regarding the likely fate of the inhaled lead which is actually retained, since the critical range determining how much inhaled lead is swallowed and how much stays in the lungs to be totally absorbed lies below 1 μ.

B. The Fate of Lead in the Body

1. The Skeleton

The outstanding fact concerning the metabolism of lead is its affinity for bone. Under conditions approximating the steady state, more than 90% of the lead in the body is in the skeleton. Yet, surprisingly little is known regarding the mechanism of of deposition or the metabolic influences which modify the interaction of lead with bone. Since the lead deposited in bone is not generally considered toxic, most investigators tend to look upon it as a rather uninteresting, inert pool of metal. It is not known precisely in what manner lead is deposited in bone. Early investigations showed the perfused pulverized bone gained lead in proportion to the calcium lost, suggesting ionic exchange in hydroxyapatite (2). More recently, X-ray diffraction studies have suggested that lead actually assumes position within the bone crystal, either by ion exchange or by occupation of lattice interstices (24). This does not preclude the possibility of other mechanisms such as discrete deposition of lead salt crystals and binding to the organic matrix. The similarity of bone lead metabolism to bone calcium metabolism has been demonstrated in numerous ways. It has been demonstrated repeatedly that shortly following administration, lead concentrates in areas of active bone formation, in proportion to the degree of calcium deposition. Some of the most elegant studies of this kind were done using the technique of autoradiography long before it became a popular tool (25). As is the case with calcium, parathormone enhances the mobilization of lead (2).

It is generally assumed that, with the passage of time, absorbed lead becomes progressively more deeply buried in the bone matrix and correspondingly less mobile and less of a hazard. However, a potentially dangerous pool of exchangeable lead is thought to persist for months or even for years. It was no uncommon in former years to encounter episodes of acute poisoning long after exposure to abnormal amounts of lead had ceased. Precipitating factors were acute and chornic infection, post-operative acidosis, alcoholism, and fractures (26, 26a). There is no body of experimental evidence to substantiate these observations, except in regard to the effects of acidosis. But even here, the only demonstrable effect is moderate enhancement of lead excretion, unaccompanied by actual precipation of toxic episodes. Lack of adequate evidence does not imply refutation. It is quite possible that the appropriate circumstances could conspire to release a toxic amount of lead from the bone, and it should be emphasized that only a small fraction of the total bone pool need be mobilized to add an appreciable increment to the small soft tissue pool.

2. *The Soft Tissues*

The pattern of lead distribution elsewhere in the body is very much dependent upon the conditions of exposure. The fate of a single dose of lead is initially strongly influenced by the vascularity of organs and systems. If sufficient time is allowed for something approaching a steady state to be achieved, a picture emerges which reflects inherent affinities for lead. Studies have been made of the distribution of lead in tissues from people not exposed to abnormally high amounts of lead. The data are presented in Table II. It is evident that the range is considerable, depending upon the organ and upon whether the calculations are based on wet weight or on dry ash weight. It has recently been found that lead, at extremely low concentrations, is an effective nucleating agent for inducing the formation of calcium phosphate crystals (27). This property may serve to trap lead at the surfaces of bone crystals and it may also be important in pathological processes of soft tissue calcification. Among the soft tissues there are very considerable differences in affinity for lead about which little is known. These differences may bear some relation to the factors regulating extra-osseous calcium metabolism.

TABLE II.—CONCENTRATION OF LEAD IN THE NORMAL ADULT POPULATION

Tissue	Per gram wet weight	Per gram ash
Bone	[1] 14	[2] 69
Kidney	[1] 1.2	[3] 110
Liver	[1] 1.2	[3] 130
Aorta	[1] 1.2	[3] 170
Muscle	[4] .17	17
Brain	[1] .075	[3] 5

[1] Calculated from the data presented, using the values provided by Tipton in the case of soft tissues and using a factor of 5 for converting bone ash to wet weight bone.

[2] Nusbaum, R. E., Butt, E. M., Gilmour, T. C., and DiDio, S. L. (1965). Relation of air pollutants to trace metals in bone. Arch. Environ. Health 10, 227.

[3] Tipton, I. H. (1960). The distribution of trace metals in the body. In "Metal-Binding in Medicine" (Seven, M. J., and Johnson, L. A., eds.) pp. 27–42. Lippincott, Philadelphia, Pa.

[4] Vallee, B. L. (1959). Trace metals. J. Chronic Diseases 9, 74.

3. *The Transportation of Lead*

As was stated earlier, the static profile of lead distribution described above is the one seen only after conditions approximating a steady state have been achieved. It bears no great resemblance to the profile seen shortly after the administration of a single dose of lead. Initially, a dose of lead moves into tissues more or less in proportion to their vascularity and intrinsic affinity. During the period or re-equilibration which follows, the fraction of the dose appropirated by the bone rapidly becomes dominant. The manner in which lead circulates in the blood has been studied rather extensively. The gross feature regarding which there is little disagreement is with regard to the distribution between the cellular elements and the plasma. More than 95% of the lead circulating in the blood is associated with the erythrocytes, and the remainder is in the plasma. This has been demonstrated to be true both *in vivo* and *in vitro*. The kinetics of uptake and release suggest that lead is deposited on the surface of the red cell as an aggregation of lead phosphate (28). This view seemed to these investigators to be compatible with the observation that strong chelators such as EDTA and hexametaphosphate were far more effective in preventing deposition on the cell than they were in accelerating desorption. Their observations may have validity for the initial stage of association between lead and the erythrocyte, but other observations suggest that lead becomes associated with deeper, less accessible structures of the cell within a relatively short period of time and probably not in an aggregated state.

Since the slow desorption induced by EDTA is offered as evidence of an aggregated or precipitated type of deposition, it follows that other chelating agents should likewise cause only a slow desorption. Such is not the case when dimercaprol is administered to animals. In this case, the desorption is extremely rapid and of much greater magnitude than when EDTA is administered (29.) Much work has been done concerning the movement of lead into and out of erythrocytes because they are so easily manipulated. The subcellular distribution of lead in liver and kidney cells has been studied to some degree. It has been demonstrated that lead distributes to all major subcelluar fractions of these organs (30). It is not likely that these observations were artifacts incurred during the preparative stages since a changing pattern of distribution was observed at varying times following administration of lead to the animals.

The nature of the form of lead circulating in the phasma has been studied only to a very limited degree, and only *in vitro* because of the extremely low concentrations found *in vivo*. It has been observed that lead added to blood plasma is not readily dialyzed (31). This is not due to the formation of a precipitate as is the case when lead is added to Krebs-Ringer bicarbonate solution (28). The nature of the binding to non-diffusible plasma constituents (presumably protein) is not understood.

4. *The Excretion of Lead*

The major route of lead excretion is the gastrointestinal tract. This is readily demonstrated following intravenous administration. Virtually all of the lead excreted into the bowel is contributed by the bile (17, 32). The excretion of lead into the urine is probably not as great as is excretion in the bile although few direct comparisons have been reported. The excretion of lead in the urine is quite slow. For that reason, the mechanism has not been easy to study. The major problem is not the determination of lead in the urine but rather the concurrent determination of the free unbound fraction in plasma, which is vanishingly low. Recently, the rate of lead excretion has been measured over a range of glomerular filtration rates (G.F.R.) in man and dog. Since the rate of lead excretion paralleled the changes in G.F.R. and extrapolated to zero excretion at zero G.F.R., it was concluded that lead excretion is essentially by a process of glomerular filtration without significant tubular secretion or reabsorption. The excretion was somewhat less in relation to G.F.R. at high levels of excretion, suggesting tubular reabsorption in this case (33).

Other routes of lead excretion probably play only an extremely minor role in the overall metabolism of lead. Mucous glands and the epithelial linings of the gastrointestinal tract, for example, contribute very little to the gastrointestinal secretion of lead. The excretion of lead in milk has been of special interest because of the possibility of transferring toxic quantities of lead to infants. It has been found in concentrations of the order of 0.01 μg/ml in the milk of normal cows (34). This is hardly of any consequence either from the standpoint of overall lead metabolism or from a toxicological point of view.

5. *Kinetic Aspects of Lead Metabolism*

It is probably evident to the reader that lead is a highly cumulative poison and that long-term exposure is potentially hazardous at some daily level of intake far below the acute toxic dose. At the time tetraethyl lead was introduced as a fuel additive, very little was known concerning the quantitative features of lead metabolism when given over prolonged periods of time, particularly to man. Kehoe's group attacked the problem in the most direct fashion by doing painstaking balance studies on a small number of human volunteers over periods of years. These studies provided baseline data of considerable value in regard to the relation between levels of lead intake and total body burden. The major limitations inherent in this approach were the small number of people involved and the lack of information available as to the fate of lead within the body.

Kehoe and his group were quite aware that most of the lead being administered to the volunteers was being localized in bone and that the potentially hazardous actions of lead probably involved the much smaller fraction of the body burden in the soft tissues. Measurement, therefore, was made of the lead in blood on the premise that this would likely reflect fairly accurately the exchangeable lead pool, which in turn would bear some reasonable relation to the concentration of lead in sensitive tissues.

A. *The Metabolism of Small Doses of Lead in Man.*—The Cincinnati studies established that the mean dietary intake of lead for adult Americans is approximately 0.30 mg/day when the considerable fluctuations from time to time for a given individual are averaged out.

About 10% of this amount (0.03 mg/day) is actually absorbed. An additional 0.01–0.03 mg/day was estimated to be contributed to the body burden by inhalation. Thus, while the daily oral intake is considerably greater than the respiratory intake, the actual contribution of air to the body burden really approaches rather closely the contribution made by food and water. Kehoe concluded from his studies that the average American adult is essentially in balance (35, 36). However, his experimental results are compatible with a small continuing accumulation of lead. The data he has presented concerning the metabolism of small amounts of lead superimposed upon the normal level clearly indicate accumulation. In these studies, single individuals received, respectively, 0.3, 1.0, 2.0, and 3.0 mg Pb/day in addition to the normal dietary lead (Fig. 1).

It should be noted that these subjects were receiving lead for up to somewhat more than three years, and more important, that the subjects showed no evidence that they were approaching an equilibrium with regard to net balance of lead in the body. By contrast, while the total body burden was continually increasing, the blood concentration of lead seemed to plateau rather early (Fig. 2). This suggests that the exchangeable body burden was attaining equilibrium and that it bore no direct relation to the total body burden, an interpretation which is compatible with the kinetics of metabolism of bone-seeking elements in laboratory animals. If the bone is acting as a sink or trap, much of the lead is no longer available for excretion, and one would expect that cutting off the lead intake would not cause much reduction in the total body burden. Actually, Kehoe's data show that cutting off lead intake *did* cause a substantial reduction of the body burden in the one subject receiving 2 mg Pb. Such an effect was not clearly apparent in the other cases. More information is needed concerning these seemingly incompatible observations.

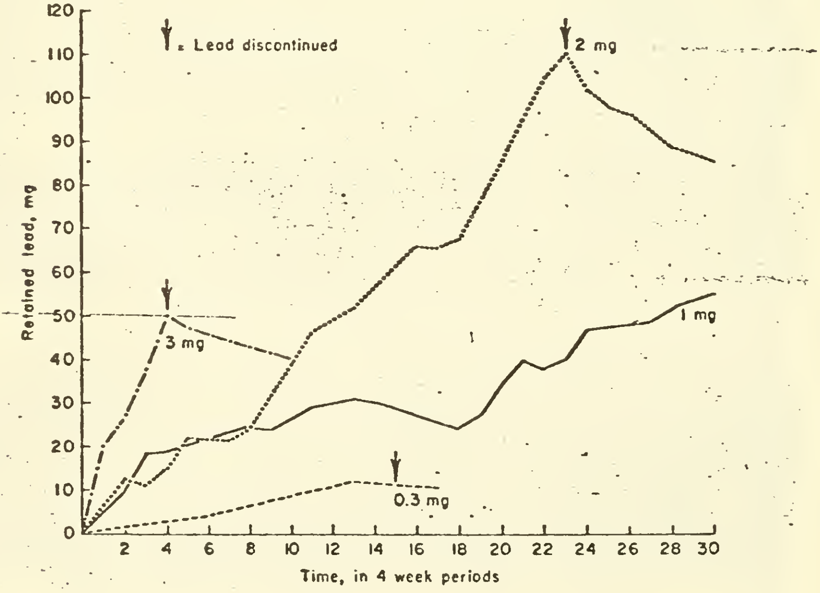


Fig. 1. Retention of lead in four human subjects at daily doses of 0.3, 1, 2, and 3 mg Pb. Modified from Kehoe (18).

Some recent findings indicate that the concentration of lead in various soft tissues as well as in bone continues to rise from birth through the fourth or fifth decade of life (40). The implication is that the relatively rapid attainment of a plateau of lead in blood during constant daily intake is not an accurate reflection of what is going on even in soft tissues under such circumstances. The concentration of lead in soft tissues may, after all, not be directly proportional to the concentration of lead in the blood over the life span of people. This is a problem urgently in need of clarification in view of the extensive reliance placed on blood lead data for estimating human exposure.

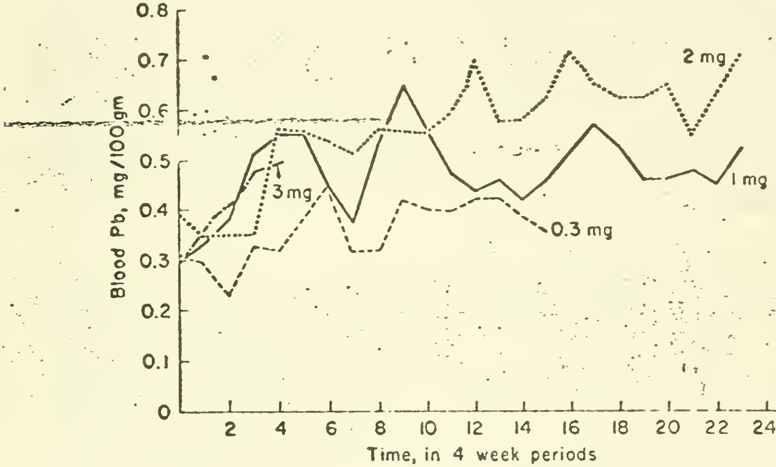


Fig. 2. Concentration of lead in the blood of four human subjects at daily doses of 0.3, 1, 2, and 3 mg.

B. *The Metabolism of Lead in Animals.*—The disappearance of foreign substances from the body can usually be described adequately by first order kinetics. According to such a model, disappearance is proportional to the amount present at any time. Thus,

$$A_t = A_o \cdot e^{-kt} \tag{1}$$

where A_o = amount in the body at time 0.
A_t = amount at time t
k = rate constant

Under conditions of continued administration a substance following first order rule will eventually attain virtual equilibrium in the body if the substance is administered continuously, at a constant rate. The accumulation is described thus:

$$A_t = \frac{A}{k}(1 - e^{-kt}) \tag{2}$$

where A = amount assimilated per unit t and A_t and k are as defined in (1). Bone seekers such as lead do not behave in accordance with the rules of first order kinetics in regard to total body retention. If retention data for bone seekers (given as a single dose) are described using conventional exponential terms, one runs into difficulties. A true final rate cannot be found in this fashion since the fraction of the body burden actually available for excretion gets progressively smaller, probably due to entrapment of a progressively larger fraction of the metal in the bony matrix. Long-term body retentions for bone seekers are best described by power functions of the form (37):

$$R_t = At^{-R}$$

where R = the fraction of the original dose remaining in the body at time t
n = a constant equal to the slope of the linear log-log plot of R against t
A = a constant equal to the fraction of the assimilated dose at $t = 1$ day

Data for retention of a single dose of lead over a period of 98 days can apparently be adequately described in this fashion in the rat (38). There is need for more thorough compartmental analysis of lead metabolism, particularly for the purpose of relating the concentration of lead in blood to the total exchangeable lead pool and to the soft tissue burden of lead. This is important because the wealth of data concerning the lead in people living under different environmental conditions consists almost exclusively of blood and urine concentrations. The concentration of lead in blood is of little direct interest because the more serious toxic effects of lead have nothing to do with the blood. The blood is mainly a useful indicator of what is going on elsewhere. Its full potential in that regard has not been adequately exploited. By way of summarizing, the likely fate of a single dose of lead is illustrated in Fig. 3.

Before leaving the subject of lead metabolism, I would like to present an additional thought concerning the role of the bone in determining the body burden of lead in various compartments. There is a tendency for some working in the area of lead toxicology to overlook the dynamic character of this system. This is pardonable. It wasn't until radioisotopes of calcium and strontium became available that the dynamics of calcium metabolism really began to be understood. Matters relating to the influence of age and disease on calcium turnover only then became amenable to detailed study. Much useful knowledge concerning lead metabolism could result from a wider acquaintance with the techniques and concepts used by those studying calcium metabolism.

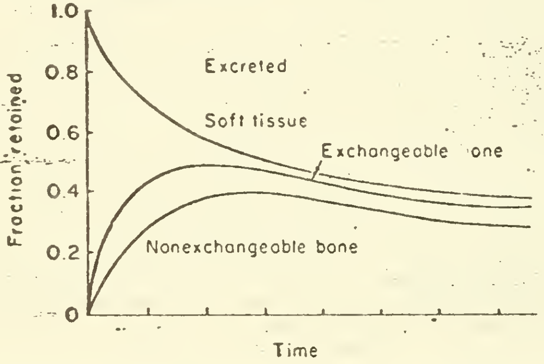


FIG. 3. The fate of a dose of lead: a guess based on evidence available.

It would seem particularly important to investigate the influence of age on the metabolism of lead in bone. In an early study of human autopsy material, it was reported that the data failed to reveal any relationship between age and the concentration of lead in the skeletal tissue (39). The statement was correct, but only because the data were too sparse to warrant any conclusions at all. In two more recent series, the data suggest that the concentration of lead in the youngest and oldest age groups is lower than in the intermediate groups (40, 41). Again, the data are too sparse, particularly in the group of very young and very old people, to warrant any firm conclusions. At best, more data of this kind would still leave unanswered any questions relating to the labile and potentially toxic lead pool in bone.

C. *The Effect of Environmental Factors on Lead Metabolism.*—It has long been recognized that the mortality and the incidence of lead poisoning in infants is much higher during the summer months than it is during the rest of the year (42, 43). The same observation has been made in the case of laboratory animals poisoned with lead (44). The mechanism has been investigated recently in rats and mice. It appears that the effect can be demonstrated independent of changes in humidity, but toxicity is favored by dehydration. The most significant findings were that the enhancement of toxicity induced by high ambient temperature involved a considerable reduction of both fecal and urinary lead excretion, and that the effect on mortality was most pronounced when exposure to high temperature is delayed until after administration of the lead (45, 46).

It has also been demonstrated that exposure to light, particularly in the ultraviolet range, increases the excretion of coproporphyrin in the rabbit following administration of lead (47). It is unlikely that this effect is due to increased vitamin D activity in promoting lead absorption since the animals received the lead intraperitoneally.

XI. TOXIC EFFECTS OF LEAD

Most trace elements have at one time or another been studied with the view of determining whether they might be essential for normal function. Lead has so long been labeled a poison that serious efforts have been made only recently to establish whether or not it has beneficial effects. Reduction of the intake to a point appreciably below the usual level in rats and mice does not reduce their longevity or their rate of growth (48, 49). Therefore, it seems highly unlikely that it is essential to life. It is unfortunate that chemicals which have gained a bad reputation at certain levels of input should be assumed to have only toxic properties. This leads to the view that any biological effect elicited must perforce be undesirable. Some poisons have actions which are demonstrably beneficial under appropriate conditions. By way of example, the chlorinated hydrocarbon pesticide aldrin markedly reduces the toxicity of some organophosphates by accelerating the rate at which they are detoxified (50).

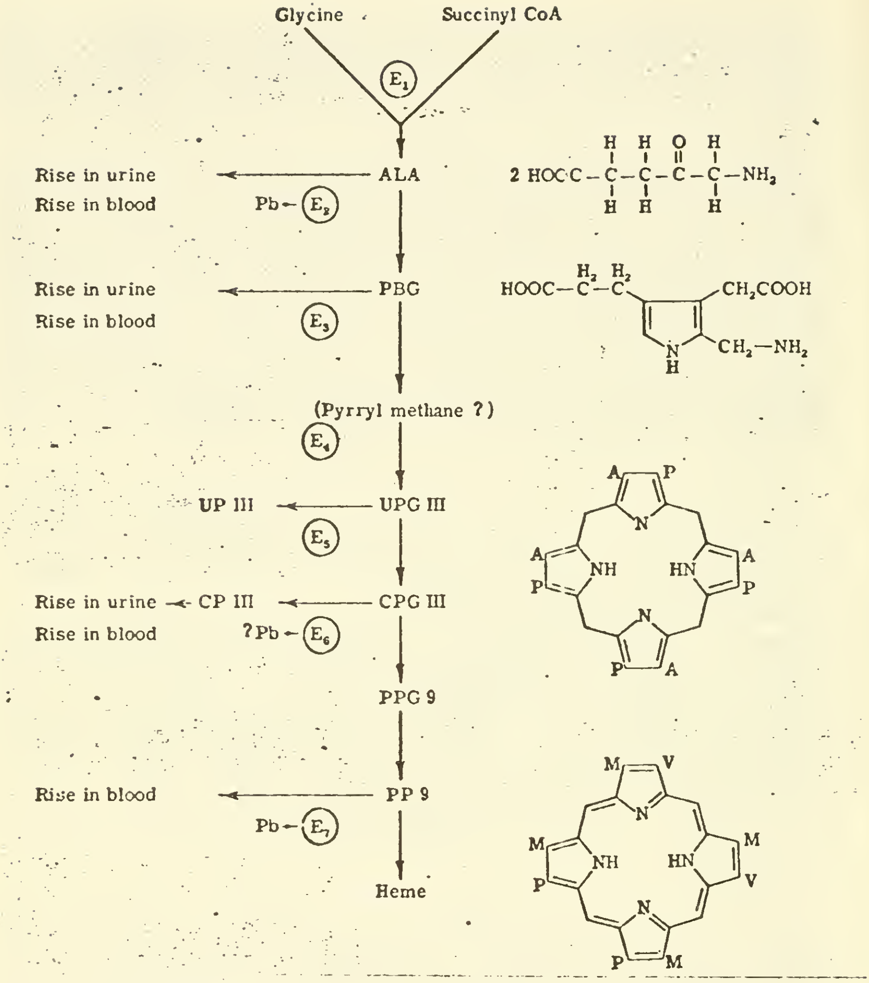
A. The Effect of Lead on the Hemopoietic System

More is known about the effects of lead on the erythrocyte and on the synthesis of hemoglobin than on any other system of the body. Yet anemia is seldom of any serious consequence in lead poisoning. Nevertheless the knowledge which has been gained in this are has proved rewarding both because it has been useful in the "preclinical sensor" sense and because it has been useful as an experimental tool in the study of porphyrin metabolism.

Theories concerning the anemia of lead poisoning were initially concerned with the question of whether the effect was due to decreased survival time or to inhibition of erythrocyte production. A considerable number of workers have studied this question by determining the survival of ^{51} Cr-tagged cells in people with lead poisoning. In many cases the survival time is abnormally short, while in others the survival time is in the normal range (51). It has been postulated that decreased survival time is due to increased mechanical fragility of the cells with consequent rupture as the cells are buffeted about in the capillaries. Mechanical fragility tests have yielded conflicting results and the cause of decreased survival is really unresolved. A decreased cell life span may also be considered on the basis of an action on erythrocyte precursors in the bone marrow with a resultant removal of the abnormal cells from the circulation by the reticuloendothelial system.

Approaches to this possible mechanism have been made by comparing the life span of stippled erythrocytes in splenectomized and nonsplenectomized animals (52). The disappearance of stippled cells from the circulation of nonsplenectomized animals as compared to their persistence in splenectomized animals suggested that decreased life span was due to destruction of these abnormal cells by the spleen. This was refuted in subsequent studies by others showing that the spleen serves to maturate the cells by causing disappearance of the stippling. Thus, "disappearance" is probably just a disappearance of the stippled feature (51).

The evidence for inhibition of heme synthesis by lead extends back to 1880 when porphyrinuria was first demonstrated in human cases of lead poisoning (53). Since that time much has been done to clarify the inhibition by lead of heme synthesis from glycine. The appearance of two major intermediates in the urine, δ-aminolevulinic acid and coproporphyrin III has proved valuable in evaluating lead exposure because their concentrations are elevated before signs of poisoning occur, as well as because elevated values during clinical poisoning are useful in arriving at a correct diagnosis. The pathway for heme synthesis is depicted, as well as the points where lead is known to exert an inhibitory effect (Fig. 4).



Enzymes

E_1 = ALA synthetase
E_2 = ALA dehydrase
E_3 = PBG deaminase
E_4 = UPG isomerase
E_5 = UPG decarboxylase
E_6 = CPG oxidase, CPG decarboxylase
E_7 = Heme synthetase
Pb-➤-= Enzyme inhibited by lead
?Pb-➤-= Enzyme may be inhibited by lead

Intermediates and by-products

ALA = Deltaaminolevulinic acid
PBG = Porphobilinogen
UPG III = Urophorphyrinogen III
UP III = Uroporphyrin III
CPG III = Coproporphyrinogen III
CP III = Coproporphyrin III
PPG 9 = Protoporphyrinogen 9
PP 9 = Protoporphyrin 9
A = Acetic acid
P = Propionic acid
M = Methyl
V = Vinyl

No intermediates between PBG and UPB III have been identified.

FIG. 4 The synthesis of heme. Modified from Haege--Aronsen, B. (1960). *Scand. J. Lab. Clin. Invest. Suppl.* 12 [47], 16.

The steps involved in the synthesis of heme were examined in detail in connection with lead poisoning after Rimington proposed that the anemia of lead poisoning was due to inhibition of heme synthesis by interfering with the incorporation of iron into protoporphyrin (PP9). It is generally felt today that this is indeed the basic cause of the anemia. Although it is recognized that other steps in heme synthesis farther back along the line from glycine are probably also inhibited, theses are not considered rate-limiting with reference to heme synthesis, since protoporphyrin accumulates. Numerous studies have been made relating the degree of abnormality in the pathway for heme synthesis to lead exposure. The investigators who have undertaken most of these studies have been concerned with industrial hygiene control measures and have therefore investigated the urinary excretion of intermediates in heme synthesis more than they have concentrations in the blood. It is generally found that the excretion of ALA in the urine is considerably more sensitive as an index of exposure than is the excretion of CP or PBG (54, 55). In a recent study comparing urinary CP and ALA, blood ALA dehydrase and certain serum enzymes to the urinary excretion of lead, the inhibition of ALA dehydrase activity was observed to be the most sensitive index of exposure (56). Elevated excretion of heme precursors may be a better set of criteria by which to assess hazard than is the excretion of lead in urine or concentration of lead in the blood.

The argument has been made that the elevation of heme precursors actually measures a body response, which is more relevant to questions of toxicity than is the concentration of lead *per se*. Furthermore, the excretion of lead in the urine is known to fluctuate wildly even under carefully controlled conditions of lead intake, and the concentration of lead in the blood also fluctuates appreciably (see Fig. 2). In a recent study of correlations involving heme intermediates and lead in the urine, the chelating agent penicillamine was used to accelerate urinary lead excretion. The correlation between ALA in the urine and lead in the urine following penicillamine was far better than between ALA and spontaneous lead excretion or than between CP and lead in the urine, with or without penicillamine (57). By manipulations of this kind one might ultimately find a near-perfect correlation between two indices of lead exposure and still be very much in the dark as to what to do with the information since there is no single really superior index of toxicity or potential toxicity to which other indices may be compared. In the case of lead poisoning in infants, there may be a relationship or at least a good correlation between inhibition of ALA dehydrase and the clinical status of the patient. Chisholm (58) has made the interesting observation that the transient deterioration of the patient which sometimes occurs following initiation of therapy with EDTA is accompanied by elevation of the plasma concentration and the urinary excretion of ALA. This effect would more likely be due to translocation of lead to sensitive tissues than it would be to any toxic action of the heme intermediates since these are relatively nontoxic, as was pointed out by Chisholm.

Heme is not exclusively synthesized by erythrocytes for the production of hemoglobin. Other tissues utilize heme in the elaboration of enzymes such as catalase and cytochrome. The enzymes and precursors leading to the synthesis of heme are widely distributed in the body. Beef liver ALA dehydrase has been shown to be partially inhibited by lead *in vitro* (59), but the ALA dehydrase from liver, spleen, blood and kidney of rabbits poisoned with lead is not inhibited (60).

The study of ion fluxes in and out of erythrocytes is a popular sport, and certainly an interesting and useful one. The actions of all the major toxic metals on Na^+ and K^+ fluxes have been studied to some degree (61). Lead causes a net loss of K^+ from cells with a reduction of ATP (62). This occurs without a concomitant uptake of Na^+ (63). In a recent study, it has been demonstrated that red cell membrane Na^+/K^+ ATPase activity is somewhat reduced in subjects with either clinical lead poisoing or with biochemical criteria of excessive lead exposure (64), (65). The correlation between ATPase activity and some commonly accepted biochemical criteria of excessive lead exposure, e.g., urinary CP and concentrations of lead in the blood was not good. This does not seriously mitigate against the significance of the observation. As was pointed out earlier, all indices are fallible barometers of toxicity or potential toxicity and no one index stands out as being so clearly superior to the rest, that is can serve as the standard by which to judge the others.

B. Effects of Lead on the Central and Peripheral Nervous System

The effects of lead on the brain are still of major concern in view of the continuing high infant mortality rate. Surprisingly little has been done to gain an understanding of the pathogenesis of lead encephalopathy. It is generally felt that experimental animals are inappropriate models. However, no systematic effort has ever been made to study infant animals of various species, in spite of the fact that encephalopathy in man is almost uniquely a disease of the infant. The fact that adult and juvenile animals are resistant to lead encephalopathy should hardly discourage anyone from believing that animals might be appropriate subjects for study. Note, however, that entire lifespan of most experimental animals is less than duration of childhood in humans. If anything, the resistance of adult and juvenile animals is quite consistent with the situation in man. Some attention has recently been given to the use of infant animals. It has been demonstrated that an encephalopathy can be produced in the infant rat by transfer of lead to the infant through the mother's milk (66). The mothers were seemingly unaffected by the dietary lead, attesting to the profound age-related difference in susceptibility. The lesions produced in the infants were reported to be quite similar to those seen in the human infant (67). These were vascular damage, serious exudation, and cellular proliferations. More direct evidence of increased vascular permeability was provided by the fact that the brains of poisoned animals became deeply stained with trypan blue administered intraperitoneally and were similarly permeated by the contrast medium Thorotrast, as revealed by electron microscopy (68).

Peripheral neuropathy at one time was commonly encountered in man as a result of prolonged occupational exposure. Axonal degeneration in "lead palsy" was frequently described, although there was some controversy as to whether the condition was most commonly myopathic or neuropathic. Demyelination and axonal degeneration has been readily produced experimentally in the guinea pig and has been studied in regard to conduction velocity of affected nerves (69). The pathogenesis is not understood. It is possible that it is in some manner related to the actions of calcium, which are numerous and diverse in the myoneural apparatus. One clear example of a calcium-lead interaction was provided in a study of the effect of lead on synaptic transmission. Lead blocked both impulse transmission and acetylcholine release in the superior cervical ganglion of the cat. This effect was reversed by calcium (70). In the light of present knowledge concerning the normal role of calcium in the release of acetylcholine at synaptic and neuroeffector junctions, it would seem plausible that lead is acting, in this instance at least, as a competitive inhibitor of the release mechanism.

The school of Russian toxicologists—as with the Russian biologists in general—has long been strongly influenced by the teachings of I. P. Pavlov who is best known for his pioneer work on conditioned reflexes. In establishing tolerance limits for environmental poisons, the Russians rely heavily on the use of conditioned reflexes as a working standard for evaluating toxicity. They claim that alterations of conditioned reflexes is often a more sensitive index of toxicity than are more conventional measurements. Their approach has recently been described in a readily available English-language publication (71).

An extensive investigation of the effects of lead on the conditioned reflexes of rats indicated that alterations in patterns of conditioned responses were evident after long-term, low-level exposure to an atmospheric source of lead oxide (72). Three conditioned reflex patterns were established in young rats. Two were positive responses, to a light and to the sound of a bell. The third was a negative (avoidance?) response to a buzzer. Exposures to lead were for single six hour periods in each day. The concentration of lead in the atmosphere during the exposure period was at two levels: 11 $\mu g/m^3$ and 1.1 $\mu g/m^3$. The higher level of exposure resulted in a progressive increase in the latent period of response to the stimuli and in a decrease in the force of response while the lower level had no effect.

TABLE III.—LEAD IN RAT BONE ASH AS μSG/GM

Rat No.	Control	Rat No.	Exposed to 1.13 $\mu g/m^3$	Rat No.	Exposed to 11 $\mu g/m^3$
4	10	7	30	3	200
6	10	8	30	10	100
15	20	9	20	12	170
17	20	14	20	13	100

Usually, an effect was seen within three months and could be demonstrated to return to the pre-exposure level within a month after exposure was terminated. Very little was done in the way of relating these exposures to usual criteria of exposure. However, the concentration of lead in the bone of the rats was reported for four rats from each experimental group (Table III). Although there was evidence of considerable accumulation of lead at the level of exposure causing alterations in conditioned reflex responses, it is interesting to note that this concentration is not much higher than is reported for normal urban man (see Table II).

Parallel exposure studies were conducted on rabbits, but they were not subjected to conditioned reflex tests. Study was made, however, of their porphyrin excretion. CP excretion was elevated in a group exposed to 10 $\mu g/m^3$, but it cannot be assumed that a similar elevation would have occurred in the rats, since rats appear to be less sensitive to the disturbances of heme synthesis than are rabbits.

Present American industrial standards consider 200 $\mu g/m^3$ to be an acceptable level of occupational exposure, about 20 times the level altering conditioned reflexes in the rat. In relation to general atmospheric pollution, the concentration of lead in the air of at least three major American cities is approximately 1.88 $\mu g/m^3$ (73). It should also be kept in mind however, that general atmospheric air is breathed 24 hours per day, and not just 6 hours per day, as was the case in these studies.

C. Effects of Lead on the Kidney

There is frequent reference in the older literature to toxic effects of lead on the kidney, usually associated with chronic poisoning. The changes described were those of a slowly contracting organ with arteriosclerotic features. Most of these older cases were due to occupational exposure. The mortality rate from chronic nephritis in Great Britain during the years 1921–1923 was twice as high among exposed workers as it was in the general population of the same social class (74). It is considered doubtful that recent levels of occupational exposure have been hazardous in this respect (75). Lately there has been a renewal of interest in the association of chronic nephritis with lead poisoning. It had long been recognized that the mortality rate from chronic nephritis in Queensland, Australia was far higher in juveniles and young adults than it was elsewhere in Australia. It was strongly suspected that the cause was childhood lead poisoning. A careful follow-up study of recorded cases of childhood lead poisoning in Brisbane, Queensland revealed that 165 of the 401 cases traced had died under the age of 40.

One hundred and one of these deaths were classified as due to nephritis or renal sclerosis (76). More recently, a series of cases of middle-aged Queensland residents having a history of childhood lead poisoning and of chronic renal insufficiency were shown to have an abnormally large amount of mobile lead in their bodies. Mobile lead was evaluated on the basis of lead excretion in response to EDTA (77). EDTA response in a control series of nephritis cases due to other causes was clearly lower. A similar follow-up of American cases of childhood poisoning indicated that there was no associated chronic nephritis (78). The interesting feature in the Queensland study was the suggestion that an early insult can cause a slow, progressive disease in the absence of continuing high exposure. In Emmerson's series, the nephritics with a history of childhood lead poisoning were excreting lead in the urine at a level twice that of the controls, but still within the range found in a series of normal North American adults (18). Studies in rats indicate that the immature kidney is more susceptible than the adult kidney and that stresses such as unilateral nephrectomy may accentuate the toxic effect of the lead (79).

D. Miscellaneous Effects

Actions of lead have been demonstrated to occur on other organs and systems of the body. They will not be given any detailed consideration here because they are of dubious relevance to current problems, although it is impossible to rule out *a priori* the involvement of any organ or system under conditions of exposure which have not yet been studied.

Bone is generally viewed as a storage site for lead and deposition is conceived as being harmful only in the sense that a dangerous amount may shift out into the soft tissues. Since bone is a living, metabolizing tissue, it would be surpising for it to be completely resistant to the toxic effects of lead. As a matter of fact, a reduction of osteoid deposition and an increase in osteoclastic activity has been observed in experimental lead poisoning in rabbits (80). In an area of old lead workings in North Derbyshire, an osteoporotic disease of lambs has been reported from time to time, and most recently by Clegg and Rylands (81). The analytical data for lead in the blood and tissues is quite consistent with a diagnosis of lead poisoning. The lambs had abnormally fine bones with very little trabecular material. Lesions of the kidney are also quite pronounced in this condition.

It has recently been shown that rats chronically intoxicated with lead exhibited a decreased ^{131}I thyroid uptake (82) and also that lead has teratogenic effects under appropriate conditions (83).

XII. LEAD AS RELATED TO THE INCIDENCE OF DISEASES

In the long history of lead poisoning, it has occasionally been suggested that excessive exposure to lead might play a role in the pathogenesis of certain diseases, either as an essential component of the etiologic complex or as a nonessential component serving only to increase the incidence or the severity. In order to identify diseases in which lead may play a role, it is first necessary to demonstrate abnormal exposure to lead. It follows that any lead-relatedness found under conditions of abnormally high exposure cannot be proven to apply likewise to the general population. But it is important to keep in mind that once an association is established on sound epidemiologic grounds, the possibility must be considered that lead could play a role in the etiology of the same disease as seen in the general population.

Reliable epidemiologic data concerning the possible association between lead exposure and diseases are few. The only groups which have been well studied are those in the lead industries. Even here, the criteria used for defining grades of exposure are rather vague. This is understandable in view of the lack of general agreement as to how you measure "exposure." In one study of mortality statistics for workers in a battery factory, it was found that death due to cerebrovascular diseases was appreciably higher among exposed workers than it was in a control population (84). The data are presented in Table IV. A major part of the higher-than-expected death rate in the high exposure group was due to cerebrovascular disease. In the same study, no association was found between lead exposure and the incidence of malignant neoplasms.

It is comforting to see evidence suggesting that something is *not* the cause of cancer. In a study similar to the one just described there was no relationship found between lead exposure and hypertension, suggesting that cerebrovascular deaths associated with lead exposure most likely involve a degenerative action on the vessel walls (85). Coming back for a moment to Table IV, it cannot be concluded from the data that lead plays no role in cerebrovascular diseases in the general population. As a matter of fact, the apparent causal relationship in the lead-exposed group should encourage efforts to determine whether a causal relationship exists in the general population. After all, the general population has both a body burden of lead and a measurable mortality rate due to cerebrovascular diseases. Where is the zero intercept for cerebrovascular deaths in relation to body burden? Is it above the average body burden or below it, and how far above or below? Put in language fashionable among residue toxicologists, is lead a threshold or a nonthreshold toxicant? The question may be impossible to study utilizing epidemiologic methods. But that is for the epidemiologist to consider.

TABLE IV.—DEATHS FROM CEREBROVASCULAR DISEASES

Year of death	Grade of exposure					
	Low		Intermediate		High	
	Expected	Observed	Expected	Observed	Expected	Observed
Retired:						
1926–50	0.7	0	0.2	3	0.8	5
1951–61	7.2	6	3.2	3	8.5	19
1926–61	7.9	6	3.4	6	9.3	[1]24
Employed 1946–61	3.2	3	3.1	3	5.6	9

[1] $p = <0.001$.

XII. THE BODY OF LEAD IN THE GENERAL POPULATION

A. Estimates of Body Burden

In sampling large human populations, certain practical considerations determine which parameters can be used in estimating the body burden. Only excreta, blood, hair and nails can be given serious consideration. As it turns out, blood and urine have been used almost exclusively to date, and there is no reason to believe that the other options would be any better. If anything, they would likely be worse. As to a choice between blood and urine, there is little question concerning the lesser variability of the blood values in a given individual under steady state conditions (18). Furthermore, sampling contamination is less of a hazard. Above all, blood is a circulating body fluid, while urine is just a by-product subject to considerable concentration and dilution, depending on the body's state of hydration. While accepting the appropriateness of blood as the most logical specimen, we are lacking adequate information regarding some aspects of its use. It is assumed that the concentration of lead in the blood (more specifically, in the erythrocytes) accurately reflects the concentration in soft tissues, but does it? This writer is not aware of any solid studies regarding this point. It may well be that its relation to the concentration of lead in soft tissue varies with age, sex, blood type, or a variety of other influences. In any case, the concentration of lead in the blood cannot be accepted as an infallible measure of the soft tissue burden.

B. Environment and the Body Burden

An extensive survey of the atmospheric and biological profile of lead was conducted in Los Angeles, Philadelphia, and Cincinnati from June, 1961 through May, 1962. The results of these studies were combined with those of certain earlier studies and were published in a document entitled "Survey of Lead in the Atmosphere of Three Urban Communities," under the auspices of the U.S. Public Health Service (73). Certain consistent trends were evident:

a. The concentration of lead in the blood and urine of these urban dwellers has not increased over the past five years.

b. The concentration of lead in the blood and urine increases in proportion to involvement with conditions of high automobile traffic density (Table V).

c. Smoking makes a small but significant contribution to the concentration of lead in blood and urine (Table VI).

d. There is no evidence that the concentration of lead in the blood or urine increases with age (Table VII).

TABLE V.—SUMMARY OF CONCENTRATIONS OF LEAD IN BLOOD OF SELECTED GROUPS OF MALES[5]

Identity of group	Mean mg./100 gm.	Number of subjects
Suburban nonsmokers, Philadelphia	0.011	9
Residents of rural California county	0.012	16
Commuter nonsmokers, Philadelphia	0.013	10
Suburban smokers, Philadelphia	0.015	14
Aircraft employees, Los Angeles	0.019	291
City employees, Pasadena	0.019	88
Commuter smokers, Philadelphia	0.021	33
City Health Department employees, Cincinnati	0.021	36
Policemen, Los Angeles	0.021	155
Live and work downtown, nonsmokers, Philadelphia	0.022	11
Post-office employees, Cincinnati	0.023	140
Policemen, nonsmokers, Philadelphia	0.024	30
Firemen, Cincinnati	0.025	191
All policemen, Cincinnati	0.025	123
Live and work downtown, smokers, Philadelphia	0.025	55
Police, smokers, Philadelphia	0.026	83
Refinery handlers of gasoline, Cincinnati (1956)	0.027	86
Service station attendants, Cincinnati (1956)	0.028	130
Traffic police, Cincinnati	0.030	40
Tunney employees, Boston	0.030	60
Traffic police, Cincinnati (1956)	0.031	17
Drivers of cars, Cincinnati	0.031	14
Drivers of cars, Cincinnati (1956)	0.033	45
Parking lot attendants, Cincinnati (1956)	0.034	48
Garage mechanics, Cincinnati (1956)	0.038	152
Total		1,877

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[1] Values are those determined in the present study, except where otherwise indicated.

TABLE VI.—CONCENTRATION OF LEAD IN BLOOD AND URINE OF SUBJECTS CLASSIFIED BY SMOKING HABITS—PHILADELPHIA

Classification	Lead in blood			Lead in urine		
	Number of subjects	Mean, mg./100 gm.	S.D.	Number of subjects	Mean, mg./100 gm.	S.D.
Suburban:						
Males	23	0.013	0.005	19	0.020	0.014
Smokers	14	.015	.005	12	.026	.014
Nonsmokers	9	.011	.006	7	.009	.005
Females	58	.013	.007			
Smokers	22	.016	.008			
Nonsmokers	36	.011	.006			
Commuter:						
Males	43	.019	.009	34	.028	.019
Smokers	33	.021	.008	26	.029	.021
Nonsmokers	10	.013	.006	8	.027	.016
Females	7	.015	.004			
Smokers	4	.018	.004			
Nonsmokers	3	.012	.003			
Downtown:						
Males	66	.024	.008	53	.030	.015
Smokers	55	.025	.008	43	.030	.015
Nonsmokers	11	.022	.008	10	.029	.012
Females	40	.018	.007			
Smokers	29	.018	.007			
Nonsmokers	11	.018	.006			
Police	113	.026	.006	113	.033	.014
Smokers	83	.026	.007	83	.034	.015
Nonsmokers	30	.024	.005	30	.028	.013

TABLE VII.—CONCENTRATIONS OF LEAD IN BLOOD AND URINE OF POLICE CLASSIFIED BY AGE—PHILADELPHIA

Age, years	Lead in blood			Lead in urine		
	Number of subjects	Mean, mg./100 gm.	S.D.	Number of subjects	Mean, mg./100 gm.	S.D.
20–29		0.027	0.006	17	0.039	0.013
30–39	56	.027	.006	57	.032	.014
40–49	29	.024	.006	29	.034	.015
50–59	10	.027	.008	9	.030	.011
60 plus	1	.021		1	.025	

e. There is no evidence that the concentration of lead in the blood or urine of chronic disease patients is higher than in the general population. The final statement in this document summarizes the evaluation made of the biological data.

"It is important to recognize that the differences between the lowest and the highest of the groups, while relatively large, are well within the presently accepted range of lead levels for humans and are not significant in terms of a threat of th occurrence of lead intoxication within the groups."

The correctness of this statement depends upon one's definition of "lead intoxication." If, by lead intoxication, one is referring to the classical form of poisoning as described early in this paper, the statement is probably correct, but even here there is some reason for doubt.

XIV. THE EVALUATION OF BLOOD LEVELS

A. *"Classic" Lead Poisoning*

The minimum blood concentration of lead below which it is most unlikely that poisoning will ever occur is 0.08/100 gm blood. This is the evaluation made by R. A. Kehoe, the dominant figure in the field of lead poisoning for the past 35 years (36). He considers this to apply equally well to children and adults. The figure is seldom challenged. It is considered to apply even when a period of some weeks has elapsed following freedom from exposure (±.005 mg/100 gm). Yet, one finds references to series of cases in which values at entry have been as low as 0.040 mg/100 gm (86) and 0.021–0.040 (87) in children. These can perhaps be explained away on the basis of analytical error or misdiagnosis, but this really seems doubtful from consideration of the experience of the analysts or the clinical histories described. Cases of acute lead poisoning in cattle occur with blood levels as low as 0.035 mg/100 gm in our experience (88), and the average normal level is 0.013 mg/100 gm, which is quite close to the level for suburban, nonsmoking people (Table VI). This observation is offered gratuitously with no implications intended as to relevance to lead poisoning in man. Information concerning the relation between the range of blood levels and signs of poisoning is not available in other species.

B. Lead-Related Diseases

Assuming for the moment that, in some cases, moderate exposure to lead contributes to the morbidity or mortality rate of some diseases not usually labeled lead poisoning, what level of lead in the blood is associated with such an effect, and for how long, and in what stage of life must this concentration be attained? Obviously, these questions cannot be answered. Blood levels will never of themselves prove or disprove the involvement of lead in the etiology of diseases. Only painstaking epidemiological studies backed by appropriate experimental confirmation will ever do this, but the determination of lead in the blood will be a vital tool in estimating exposure to lead in such studies, particularly since this is about the only measure of body burden gathered from the general population to date. It certainly does seem that the threefold range of differences in blood lead levels tabulated for different populations in Table V offers some opportunity for epidemiological studies of the relatedness or nonrelatedness of lead to the incidence of diseases.

XV. THE ROLE OF ANIMAL EXPERIMENTATION

The evaluation of the hazards of lead to man using experimental animals is a hazardous occupation, particularly so in regard to the study of the possible association between lead and human diseases. The obvious starting point is an in-depth comparison of "classic" poisoning in animals to "classic" poisoning in man. The rabbit has already been subjected to a rather extensive study with this in mind (80). Further efforts along this line are needed. Meanwhile, long-term, low-level feeding of lead to rats and mice has yielded results of potential significance for human health. In both species a life-shortening effect was demonstrated at dietary levels resulting in soft tissue lead concentrations quite similar to those of "normal" urban man (48, 49). The increased mortality was attributed to infections (89). More studies are needed to confirm and expand on these observations. It would be of interest to know whether the observed increase in mortality due to infections is a highly specific effect or whether it is a manifestation of accelerated aging.

These studies and the Russian inhalation studies described earlier suggest the possibility that for some body functions, the rat and perhaps the mouse are exquisitely sensitive to lead. This is not likely as regards mortality in the case of the rat, at least. Rats tolerate lead at 60 mg/day or more in their food or water for a year or more (79, 82, 90, 91). This would be roughly equivalent to 8 gm day for an adult man or about one third to one sixth of the single lethal dose (92). At this stage, these animal studies are merely provocative, but they may be relevant to the human condition.

XVI. THE NEW DIMENSION

The emerging concerns reviewed in this essay are symptomatic of a growing awareness that modern technology threatens to overwhelm our environment with its products, by-products, and wastes. The new dimension is a dimension of foresight. Whether lead proves to be an environmental hazard or not, deep involvement in efforts to make a determination in regard to the significance of environmental lead will equip us with new concepts and experience which will have to be directed against an ever-increasing number of similar problems.

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LEAD

"Roman culture lost it source of progress when and because its elite, endowed by heredity and/or upbringing. . . . was exterminated by various factors, above all by lead in the diet of the upper-class women . . . ." This lead to "sterility, miscarriage, stillbirth, heavy child mortality and permanent mental impairment in the children (S. C. Gilfillan, *The Mankind Quarterly*, Edinburgh, Scotland)." K. B. Hoffman and Rudolf Kobert, between 1883 and 1909, abundantly proved that the lead pots and pipes used only by the wise, intelligent, and rich Romans were primarily responsible for the rapid decline and disintegration of the Roman empire and culture.

In spite of the knowledge that has accumulated in regard to the toxicity and metabolism of lead, intoxications are on the increase. Most of them occur in children, who are more sensitive than adults. In Baltimore, nearly 800 cases of accidental lead poisoning in children occurred during the last 30 years; 124 were fatal.

Ingestion or inhalation of a toxic dose of all the salts of lead, as dust, in solution, or in the form of vapors, will induce symptoms of intoxication. These include headache and weakness, which may progress to paralysis of extensor muscles of the wrists, crapms, and pain in the legs, constipation, collapse, coma, and convulsions. After ingestion, gastroenteric symptoms are predominant. Subacute lead poisoning should be suspected in a child showing irritability, anorexia, anemia, loss of body weight, constipation, and periodic vomiting. Look for these signs and symptoms particularly during hot spells in low income groups living in quarters in which the paint on the walls is 25 years old or older. Skin absorption of lead salts is ordinarily not a problem.

It has become popular in the manufacture of illegal whiskey to use old automobile radiators as condensers in the distillation system. At the temperature of the distillation and under the conditions used, lead is dissolved from the soldered joints in the radiators; this has led to rather frequent cases of lead poisoning. See Scrap Iron, p. 407.

Intoxications from tetraethyl lead differ in several ways from other compounds of lead. L. W. Sanders points out "that tetraethyl lead intoxication exhibits itself as purely a psychotic state, for this is the pattern which invariably is seen, and yet is hardly ever identified by physicians who have not had prior experience with it" [*Arch. Environ. Health* 8, 270 (1964)]. Tetraethyl lead is readily absorbed through the lungs and the skin. It is quite soluble in fats. "Slight or brief exposure causes insomnia, anorexia, slight fall in blood pressure and body temperature and, if the exposure is more prolonged, stippled red blood cells and leukocytosis, and possibly a lead line [A. Hamilton and H. L. Hardy, 'Industrial Toxicology,' Hoeber, New York 1949]." A severe intoxication results in marked cerebral involvement (insommnia, excitement, maniacal attacks). Death may occur because of exhaustion.

Treatment: Remove the individual from the source of exposure. After ingestion of a potentially toxic dose of a lead compound, induce vomiting and follow with gastric lavage at the earliest possible time. Administer a saline cathartic and an enema. Give calcium gluconate (2 gm), atropine, papaverine, or another antispasmodic for relief of colic. If pain is severe, consider using morphine sulfate. In the case of children, do not give more than 1 mg per 5 kg of body weight. Inject *slowly* I.V. 25 mg/kg of $CaNa_2$ EDTA in divided doses during the first 24 hours. If tolerated, give 75 mg/kg I.V. in divided doses on each of 4 additional days. After a period of about a week, repeat this regimen. (Subcutaneous and intramuscular administrations of this drug have induced less dependable results).

Two severe cases of lead arsenate poisoning at the Jackson Memorial Hospital, Miami, Florida, responded favorably to the cautious alternated treatment with $CaNa_2$ EDTA and BAL. Apparently, only the lead in the blood can be chelated by dimercaprol; the lead in bone and soft tissue is too firmly bound to be mobilized. Therefore, dimercaprol used alone in the treatment of lead poisoning has been abandoned (S. C. Harvey, "The Pharmacological Basis of Therapeutics, Third Ed. The Macmillan Company, New York, 1965).

In treating lead poisoning in children, H. D. Smith prefers edetate rather than dimercaprol, in spite of the fact that after edetate there is frequently an exacerbation of the encephalopathy during the first 24 hours of therapy. He states: "Currently, following the suggestion of Chisholm, we are using dimercaprol together with edetate in the following regimen: dimercaprol 4 mg/kg/dose intramuscularly every four hours for five-six days; edetate 12.5 mg/kg/dose intramuscularly, mixed with procaine, also every four hours for five-six days. The first dose of edetate is given concurrently with the second dose of dimercaprol. Before initiating this therapy, one should make certain that the child is voiding well" [*Arch. Environ. Health* 8, 256 (1964)]. For additional information, consult the original paper. Oral edetate is not recommended.

H. Mehbod found that the amount of lead removed by peritoneal dialysis is considerably greater than that excreted in the urine, with or without edetate therapy. He recommends the combined treatment of peritoneal dialysis plus edetate: (1) in patients with acute lead intoxication when the speed with which deleading is accomplished is a crucial factor in the outcome, (2) in patients with lead intoxication who also have severe renal functional impairment and azotemia, and (3) in any patients in whom the administration of edetate in high doses may be hazardous [*JAMA* 201, 972 (1967)].

Oral penicillamine also has been recommended for the treatment of lead intoxication. According to J. Greengard of the Hektoen Institute, penicillamine has the advantage in that it is "apparently less toxic." The initial dose for older children and adults is 250 mg. This may be increased to 250 mg 4 times a day. Subsequent doses depend on the severity of the intoxication and on the amount of lead excreted in the urine [*Can. Med. Assoc. J.*, 88, 1155 (1963); *Brit. J. Ind. Med.* 23, 282 (1966); 24, 272 (1967)].

Tetraethyl Lead. Kerosene has been recommended for the removal of this compound spilled on the skin, followed by a thorough washing with green soap. According to L. W. Sanders, Sr., "No specific therapy for lead encephalography has been developed up to the present time. The treatment therefore, is essentially symptomatic and supportive. Heavy and prolonged sedation with barbiturates has been employed effectively. The short-acting barbiturates are more easily controlled, and there is less likelihood of an unexpected cumulative effect. The water and electrolyte balance of the patient must be maintained, and the maintenance of nourishment is essential, as is the careful cleansing of the air passage" [*Arch. Environ. Health* 8, 270 (1964)]. For additional information consult "Symposium on Lead" R. A. Kehoe, *Arch. Environ. Health* 8, 202–354 (1964).

LEAD NAPHTHENATE

The oral toxicity of lead naphthenate ranges from 3.5 to 5.1 gm/kg (rat). The compound can be absorbed through the skin in toxic quantities. Rasetti *et al.*

found evidence of lead absorption in 65% of 14 workers who had prolonged contact with lubricant additives containing 10% lead naphthenate. Skin absorption was found in 3 subjects rubbed with 6 ml of an oil containing 192 mg lead (expressed as metallic lead). Blood samples taken 10 minutes later showed lead absorption. Blood lead levels increased for 60 minutes and then decreased rapidly and become "normal" in 8 hours [L. Rasetti, *Rass. Med. Ind.* 30, 71 (1961)].

LEVALLORPHAN TARTRATE (LORFAN ; 1,3-HYDROXY-N-ALLYLMORPHINAN

This drug, like nalorphine, is used as an antagonist against severe respiratory depression induced by opiates and precipitates the abstinence syndrome in opiate addicts. It produces moderate respiratory depression when administered to individuals who are not under the influence of an opiate and who are not addicted. If depression is due to hypoxia, brain damage, barbiturates, anesthetics, or related drugs, even a low dose of levallorphan will *increase* the respiratory depression. The drug is *not* a narcotic and, therefore, not subject to control by the federal narcotic law.

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Lead Contamination of the Atmosphere and the Earth's Surface

(By Clair Patterson, Division of Geological Sciences, California Institute of Technology)

The following is a summary of the paper read by Dr. Patterson, April 25, 1969, in the Symposium on Atmospheric Pollution: Its Long-term Implications.

There now exists widespread pollution of the earth's surface and atmosphere by lead compounds. Atmospheric lead is the most serious contaminant. When lead enters the body through the lungs, it reaches the general circulation, whereas when ingested by mouth, it is largely excreted by the liver in the bile and discharged in the feces. A small portion of the lead, however acquired, remains in the body and when it reaches a sufficiently high level it causes lead poisoning.

Man's troubles with industrial lead began as early as 2500 B.C., when the mining and smelting of lead ores began. Since the Industrial Revolution the concentration of lead in the atmosphere, surface waters, and the oceans has sharply increased. Patterson and his collaborators have traced the rate of this increase by measuring the amounts of lead in successive annual layers of snow deposited in northern Greenland over several centuries. At about 1940 lead concentrations in snow rose abruptly and increased by a factor of three, in only two decades.

The largest source of contamination of the atmosphere at present is the petroleum industry through its production of anti-knock motor fuels containing lead alkyls. Public health agencies, Dr. Patterson stated, are not adequately facing the hazards of lead pollution.

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